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A HANDBOOK

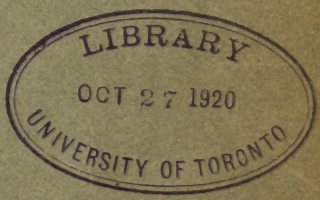
OF

BRITISH MOSQUITOES

BY

WILLIAM DICKSON LANG, M.A., Sc.D.

ASSISTANT ATTACHED TO THE DEPARTMENT OF ENTOMOLOGY



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PREFACE.

OWING to the important part played by mosquitoes of certain species in the communication of disease, an increased amount of attention has been given to the study of these insects in recent years. But if the study of any particular species of insect, no matter from what point of view, be it purely scientific or altogether practical, is to be of real value, it is essential that the species should be exactly identified.

Twenty-one different species of mosquitoes have been found to occur in the British Islands ; and it is by no means easy to distinguish every one of these species from all the rest.

It is hoped that this Handbook, prepared with that end in view, will make it possible for the student to identify all the British species without much difficulty, and not only in their adult stage as flies, but, so far as present knowledge of them will permit, in their larval and pupal stages as well.

The author of the book, Dr. W. D. Lang, has taken great pains in its preparation, and has neglected no source of information that would help to make it of value for the purpose for which it is intended.

CHARLES J. GAHAN,
Keeper of Entomology.

BRITISH MUSEUM (NATURAL HISTORY),
March, 1920.

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Plate I.—*Anopheles maculipennis* Meigen. Female.

The common malaria-conveying mosquito of Europe. Abundant in Britain.

Plate II.—*Anopheles bifurcatus* (Linnaeus). Female.

Has been known to convey malaria in Italy. Abundant in Britain.

Plate III.—*Anopheles plumbeus* Stephens. Female.

Has been artificially infected with malaria, but not known to convey it under natural conditions. Widely distributed in Britain, but restricted during larval life to a sylvan habitat.

Outside the genus *Anopheles*, no mosquito is known to convey malaria.

Plate IV.—*Ochlerotatus caspius* (Pallas). Female.

Plate V.—*Ochlerotatus nemorosus* (Meigen). Female.

BRITISH MOSQUITOES.

I. INTRODUCTORY.[1]

A. GNATS, OR MOSQUITOES, AND OTHER FLIES.

THE object of this handbook is to render as easy as possible the identification of British Mosquitoes.[2] Anti-malarial measures, rendered necessary by the introduction of large numbers of malarious soldiers, have drawn attention to mosquitoes in Britain; and it is desirable that everyone should be able to distinguish a gnat capable of conveying malaria (*Anopheles*) from a non-malarial kind. Again, diseases other than malaria are known to be gnat-borne, though fortunately not in this country; and it is at least of interest, if not of immediate use, that our few British species should be known, in case these should be found to be concerned in conveying any disease. It is in some of the non-malarial species that difficulties of determination arise, but in most cases, with the help of reasonable magnifying power, the species are easy to distinguish; and with clear directions and figures there is no reason why everyone should not readily identify most, if not all, the different kinds.

That such help is needed is clear from a consideration of the specimens frequently sent to the Museum in answer to requests for mosquitoes from various localities. Often these are true mosquitoes, but often they are not, or are a mixed bag of mosquitoes and other flies. It is evident, then, that what is first needed is to distinguish a true mosquito, or gnat from flies belonging to other groups.

[1] All the text-figures, drawn for this work by Mr. E. Tetu, are very considerably magnified. It has not been considered necessary to give the exact magnification in each case. The Plates are reprinted from Major E. E. Austen's British Blood-sucking Flies, British Museum, 1906.

[2] The terms "gnat" and "mosquito" are used indifferently in this work. A gnat is a mosquito, and a mosquito is a gnat.

The most telling feature of a mosquito is its proboscis (fig. 6.) Other gnat-like flies may have an elongated face, even ending in a more or less pointed projection; but a gnat has a proboscis several times longer than the whole head, and easily visible on a near view of the gnat at rest. When once the proboscis is seen, there can be no doubt as to the nature of the insect, if it is gnat-like in general appearance. For there are other flies with a long proboscis; but the general build of these is so different from a gnat's build, that no confusion is possible. To describe, however, a gnat as a gnat-like fly is obviously inadequate. But for lack of any other popular word designating this type of fly, it must do duty while an attempt is made to indicate a gnat's general features. A glance at the figures (*e.g.*, fig. 6 and Plates I.–V.) of more-or-less complete gnats will give a better idea than any description. Delicacy, probably, is the quality that best describes the general build of a gnat. The body is slender and lightly built, and the legs are very long and thin; the wings also are narrow (figs. 1, 6), and the antennae long and thread-like, though densely-plumed in the male (fig. 13).[1] Another character, and one diagnostic of a gnat, is the presence of scales thickly clothing the head, legs and the "nervures" or "veins" of the wings (figs. 67, 68); and they even form a fringe round the whole margin of the wing (since the wing is limited by a "vein"); and in many cases cover the abdomen (fig. 16). But these scales are often thin and hair-like; and, since many flies are clothed with hairs where the mosquitoes have scales, this character cannot so easily be used as a criterion without a fairly high magnifying power. In those forms, however, in which the abdomen is densely-scaled (the Culicine gnats), the scales are broad and can be more readily seen. Finally, it must be borne in mind that hairs as well as scales are often present upon the thorax and abdomen of gnats; also that the scales of gnats are readily rubbed away, so that a bad specimen may appear naked.

A gnat, or mosquito, then, may be known at sight as a fly (that is, a two-winged insect) of delicate and slender build, with a long proboscis capable of use by the female for sucking blood, and having thread-

[1] Densely-plumed antennae are very noticeable in the males of some flies nearly allied to gnats, and must not be considered as peculiar to, but only as a characteristic feature of all gnats.

like antennae with whorls of sparsely-distributed hairs in the female (fig. 14) and of dense hairs in the male (fig. 13), giving the antenna of a male gnat a plumose appearance. Further, viewed under a moderately strong magnifying power, the head, legs, veins of the wings, and often the abdomen, are seen to be densely clothed with scales. If a gnat is caught, so that the venation of the wings can be examined, it may be known by arrangement of the veins. This is shown in fig. 1, and the most characteristic feature is the presence towards the tip of two parallel forked veins (longitudinal veins 2 and 4) with an unforked vein (longitudinal vein 3) lying between them and also parallel with them. The stalks of the two forked veins are continued backwards, the lower one to the base of the wing, the upper to a point on longitudinal vein 1 where it branches from that vein. The middle,

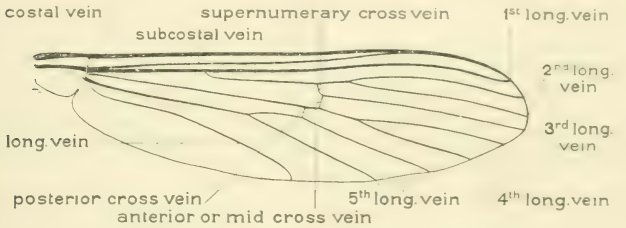


FIG. 1.—Wing of Mosquito: *Culex pipiens* (Linnaeus).

unforked vein abuts against cross-veins joining the stalks of the two forked veins.

Thus, even if a specimen is so rubbed that the scales are removed, a gnat may be known at once from other flies (except *Mochlonyx* and *Chaoborus*—allied genera which have no long proboscis) by the wing-venation. And this, as well as the presence of a proboscis, is a useful test when a gnat is compared with other flies that are frequently mistaken for true mosquitoes or gnats. Three of these will be mentioned. First, there are numerous species of *Chironomus* and allied flies that are often noticeable for occurring in immense numbers in the neighbourhood of water, and have a very gnat-like appearance, especially the males with their densely-whorled antennae. These flies have no proboscis and are not covered with scales. The

wing-venation is shown in fig. 2, and is seen to be simpler than that of a gnat. The larvae of some of the commonest species of *Chironomus* live in water-butts in company with larvae of *Culex pipiens*—the Common Gnat; but their appearance is very different from the gnat larvae, and some are bright-red and popularly known as Blood-worms. They make a more-or-less coherent case of slime and dirt, and live in it on the bottom; while *Culex*-larvae swim freely at all depths and

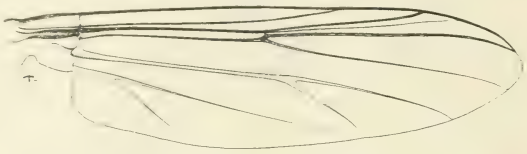


FIG. 2.—Wing of *Chironomus plumosus* (Linnaeus).

frequently rest at the surface. The *Chironomus*-fly is interesting for its habit of raising a pair of legs and waving them in the air like feelers when it is resting and when danger threatens. Mosquitoes have the same habit, but while *Chironomus* raises its fore-legs, mosquitoes raise their hind-legs. Doubtless correlated with this habit is the great length of the fore-legs in *Chironomus* and of the hind-legs in mosquitoes.

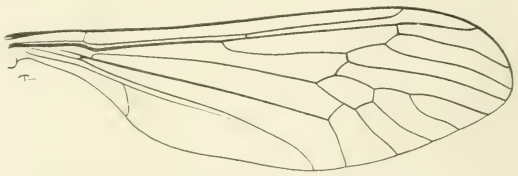


FIG. 3.—Wing of *Trichocera regelationis* (Linnaeus).

Other flies constantly mistaken for true gnats are certain gnat-like kinds of the family Limnobidae, for instance, species of the genus *Trichocera*. These are familiar for dancing in small swarms in sheltered situations throughout the winter, and are, consequently, sometimes known as Winter-gnats. The build of a mosquito was described as delicate; that of a *Trichocera* may be called flimsy, so fragile are these flies even compared with gnats. There is, of course, no long proboscis; and the bodies are bare or but slightly hairy.

The wings are broader than mosquitoes' wings, and the venation is far more complex (fig. 3). The larvae are not aquatic.

Rhyphus fenestralis is a very common fly frequently mistaken for a mosquito. It is found in houses, outhouses, etc., often in company with *Anopheles maculipennis*. Having spotted wings (fig. 4), at first sight it superficially resembles that species. The wings, however, are wider, and the spots consist of the pigmented wing-membrane; whereas, in *Anopheles maculipennis*, they are formed by scales massed more thickly there than elsewhere along the veins. Besides, *Rhyphus* has no scales, no long proboscis, and its build is more thick-set than that of a mosquito.

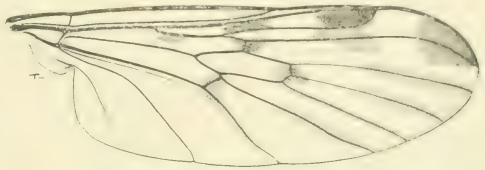


FIG. 4.—Wing of *Rhyphus fenestralis* Scopoli.

B. THE LIFE-HISTORY OF MOSQUITOES.

The *eggs* of British mosquitoes are laid during the warmer parts of the year generally on water, either singly (by the genera *Anopheles*, *Aëdes*, *Ochlerotatus* and *Finlaya*), or glued together in floating masses called *rafts* (by *Taeniorhynchus*, *Theobaldia*, *Culicella* and *Culex*). As far as they are known, the eggs of all species float, and are several times longer than wide. In most species they remain from one to several days before hatching, and the length of time is probably more determined by the temperature than by any other cause. The emergent larva (figs. 10 and 11 show a full-grown larva) is an elongate, limbless grub with a wide thorax and head, and with variously-shaped and often tufted hairs symmetrically arranged along its whole length. Some of the most remarkable of these hairs are a pair of very dense tufts called *brushes* (figs. 10, 11 and 12), lying on the underside of the head in front of the mouth, and resembling a moustache. These the larva continually moves backwards and forwards, and thereby entangles in them the particles of organic

matter on which it feeds. These particles are then combed out of the brushes by some hairs which grow on the mandibles, and passed into the mouth. Other particles are swept by the current created by the brushes on to the other mouth-parts and entangled in them.[1] Thus the larva feeds and grows, and in a few days undergoes *ecdysis*, that is, its skin splits, and a second larval form, or *instar*, emerges, resembling the first in general features, but differing in detail. In all the British species of which the first larval instar has been examined, the group of hairs (fig. 11, FIN) lying medianly and ventrally on the last abdominal segment, and forming the fin-like organ characteristic of mosquito larvae, is absent, but is assumed at the first ecdysis or moult by the second larval instar. There is also a minute tooth or *egg-breaker*[2] on the surface of the head of the first instar, having a vertical motion produced by muscles attached to its base, and used for forcing an exit from the egg. The third and fourth larval instar closely resemble the second, but are progressively larger and are of longer duration. Indeed, some forms (*e.g.*, *Anopheles bifurcatus*) spend the whole winter in the third or fourth larval form, but otherwise the stages are generally run through within a few weeks. The larva moves in wriggling jerks, and an *Anopheles*-larva can dart backwards with great nimbleness. The larva frequently rests just beneath the surface, and there can breathe by means of a pair of stigmata placed one on each side of the mid-line of the penultimate segment (the eighth abdominal), and placed in the Culicine gnats at the end of a long tube —the *siphon*. While thus floating, the larva explores the lower side of the surface-film and its neighbourhood for food, often bending its body sideways to reach a favourable spot. Owing, presumably, to the action of the brushes, it is kept gently moving forward while feeding, whether it is floating on the surface or browsing on the bottom as it sometimes does, especially in certain species ; and when a Culicine larva on the surface curves round as just described, it takes on a rotary motion, circling round the axis of its siphon. Should the stigmata tend to become clogged, or breathing be otherwise obstructed, the larva bends round and passes the siphon through the brushes,

[1] *See* G. H. F. Nuttall and A. E. Shipley, 1901, Journal of Hygiene, vol. i., p. 57.

[2] *See* F. W. Edwards, 1919, Annals and Magazine of Nat. Hist., Series 9, vol. iii., pp. 372–6. It is shown below in figs. 98–99a (p. 55), in the mid-line of the head and just posterior to the centre.

apparently to clear away the obstruction, just as a cat uses its teeth to clear its fur. This action is one of the first signs of distress exhibited by the larva in an unfavourable environment, even when it brings no relief, as when the surface of the water is covered with paraffin. Four finger-like, delicate processes, the *anal gills* (figs. 10, 11), project from the end of the last (ninth) abdominal segment, and probably allow the larva to remain longer beneath the surface than

FIG. 5. Pupa of *Taeniorhynchus*.

would be the case if it were dependent for breath upon its stigmata alone. This accessory breathing-apparatus would also explain how a hibernating form can remain alive in the mud while the water above is frozen at the surface.[1] Again, the larva of *Taeniorhynchus* lives

[1] It has been shown that certain mosquito larvae can remain [illegible] aerated water for a considerable time after the removal of the anal gills, [illegible] probably through the general integument. See J. W. S[illegible] Manch., 1917, Lit. [illegible], vol. vii., pp. 277–295.

continually on the bottom, and has a siphon modified for piercing submerged plants and obtaining from them the air it needs.

The instar succeeding the fourth larval instar is a pupa. It does not eat, and, except when disturbed, floats just beneath the surface of the water. Like the larva, it can swim by wriggling jerks, but is far more nimble and restless when alarmed. It is also more buoyant than the larva, and this buoyancy becomes progressively greater as the time for emergence approaches. The pupa has a very different aspect from the larva (fig. 5). Generally speaking, it resembles a comma with a gigantic dot. The dot of the comma is the head and thorax of the pupa, and the tail its abdomen. The abdomen ends in a pair of lobe-like fins or *paddles*. The outline of the sheath covering the rudimentary wings can be seen on the sides of the thorax as in the chrysalis of butterflies, and the sheathes protecting the future legs, mouth parts and antennae of the fly are prominent on the surface of the pupa. As in the larva, there is a single pair of large stigmata or breathing pores, but in the pupa they are placed on the thorax, and prolonged into expanding funnels standing out from the thorax like ears.

The pupal instar is of short duration, generally lasting but a few days. Before emergence the pupa begins to acquire a silvery look, due to air that is forced between the pupal integument and the enclosed imago. This air causes a greater buoyancy of the pupa, which is increased as more air is forced in, and the pupa appears more silvery. It is then with difficulty kept from the surface and sometimes fails to retain its equilibrium, temporarily rolling over to one side or the other. It rides so high in the water that finally the dorsal surface of the thorax projects and remains dry. This dry patch then splits along the mid-line, and very quickly the thorax of the imago is pushed out. The gnat thus emerges in a humped attitude, with its head sunk on its breast, the antennae, palps, proboscis, and legs still held in their pupal sheathes, and the abdomen but little outpushed from the pupal skin. The imago still continues to move vertically upwards, with the dorsal surface of the thorax foremost, the antennae and proboscis closely appressed to the thorax, and the legs, with their tips still in their pupal sheathes, lying along the emergent abdomen, the tip of which is also still encased. In this condition the floating insect appears most

unstable, with the thoracic mass high above the centre of gravity of the system. But, in fact, its equilibrium is by no means easily disturbed, as may be proved by gently blowing upon it, when it spins round most readily, like a weather-cock, but does not capsize. Indeed, an upset in this stage would be fatal, as, once wet, the insect could not resume its vertical position, and would drown. The pupal skin, split open and completely emptied of the air that forced out the imago within, no longer rolls to this side and that, but lies steadily on the surface without rocking. Gradually the emergent fly draws its limbs free, the wings harden, and it flies away.

The habits of various species differ, but generally British mosquitoes hide away during the day and in chilly weather, and fly forth in the evening if the weather is warm enough. It is mostly then that the females bite and the males swarm. The males do not suck blood, but some have been observed feeding upon flowers. It is the habit of the males to dance in swarms in the evening at definite sheltered spots, sometimes in company with the males of other species of gnat or of gnat-like flies. The females wander about singly, and when one approaches the neighbourhood of swarming males, the swarm becomes very agitated and the dance a frenzy. The stimulus exercised by the frenzied swarm breaks down any inhibitions controlling the female, who, throwing away reserve, darts into the swarm, is seized by a partner, and the couple fall out of the dance. The swarm then resumes its normal motion and awaits the arrival of another female. It thus appears that the swarming of the males is no aimless behaviour, but has a bionomic significance, producing the requisite stimulus that, reacting on the female, leads to her attraction and capture, thus unlocking a whole chain of consecutive stimuli which produce an orderly sequence of reproductive processes.

But the stimulus of the male swarm may not in all cases be the only unlocking action. There is some evidence to show that in certain species of *Anopheles*, the female requires a meal of blood before she is ready for pairing[1]; and, after pairing, a second meal before oviposition.

[1] H. E. Annett, E. E. Austen and R. Ross, 1902. Report of the Malaria Expedition, being Memoir II. of the Liverpool School of Tropical Medicine, p. 21. It is possible that the absence of conditions suitable for swarming and not the absence of a blood-meal was the cause of the females' failure to oviposit. There is nothing in the essentials of the experiments to negative this possibility.

In such cases then, an unfed female will be indifferent to a swarm of males, desire they might so [illegible], and the chain of reproductive processes is only stimulated by the introduction of another organism whose blood provides the necessary stimulus. This introduction of a warm-blooded host as a necessary factor in the life-cycle evidently makes less secure the continuation of the species by complicating the life-history, and would not have been resorted to except as a drastic measure to meet a serious emergency. If it could be shown that in all cases even in those that regularly blood-suckers by the female stimulated reproduction, there is here a hint both as to how the blood-sucking habit, from having been casual and more or less accidental may have become general and even necessary; and as to a possible cause of extinction. For it seems clear that the mosquito's proboscis was evolved to suck plant-juices. Both sexes of blood-sucking species have been observed sucking flowers, and the females of many foreign species seldom or never suck blood. If individuals, then of primitive, plant-sucking mosquitoes appeared with the freakish habit of occasionally sucking warm-blooded animals and this resulted in stimulating reproduction in the female, it is evident that such individuals would more readily reproduce that the habit, if heritable, would be transmitted at an ever-increasing rate until the whole female population of the species was thirsty for blood—as many now are. Again, it is a fact that different degrees of stimulus are needed for pairing in different species of gnat. Generally we may say that there are three such degrees. Some species, such as *Stegomyia fasciata*, mutually readily, some require the awakening of the males like *Chaoborus*, and thirdly, some, like the *Anopheles* just mentioned, apparently require a meal of blood as well as the swarming of the males. In a general view of the animal kingdom this same diversity in the degrees of stimulus required is observable. The objection may be expressed that—In certain cases, for a short succession, the sequence of reproductive processes does not run evenly, but here and there there seems to be a slowing down that is likely to lead to a complete stop, as if there were an increasing resistance to readiness on the part of the female which can be overcome only by a correspondingly violent stimulus on the part of the male. In this both the regular needs of reproductive processes regarded in the view-point presented

as a block caused by factors inhibiting the readiness of the female increases as the race evolves, and generation succeeds generation, there will come a point at which no corresponding effort on the part of the male will overcome the female's reluctance, and the race will perish. Such a process may be in action among mosquitoes at present. The swarming of the males at first removes inhibiting factors; but later the meal of blood is needed as well; should the inhibitions continue to accumulate, a new device must be found, or the race will become extinct.[1]

Some British mosquitoes hibernate as impregnated female flies, and issuing forth in spring, lay eggs, and thus start a new cycle with the new season. Others hibernate as larvae (or, in some cases as eggs), and the imagines of these species die off at the end of autumn. In some species there appear to be but one or two broods in the year; while in others, brood succeeds brood throughout the summer; but the rate at which the life-stages are run through, and consequently the number of broods produced in a season is probably primarily determined by the temperature. Hot weather sometimes (*e.g.*, in *Ochlerotatus nemorosus*) has the effect of checking the life-history by drying up the breeding-places; but as a rule the warmer the weather, the faster the progress of the life-cycle.

C. STRUCTURAL: THE NOMENCLATURE OF PARTS

1. THE IMAGO (FIG. 6).

It is impossible to identify mosquitoes without a nomenclature of their parts. But it is not intended to discuss their morphology much further than is necessary for purposes of identification.

Figure 6 shows the parts of an imago, or fly. The *head* bears the *antennae*, the *eyes* and the mouth-parts. Most of the last constitute the *proboscis*; but the *maxillary palpi* (generally referred to simply as the *palps*) are a pair of jointed, bristle-like structures, lying one on each side of the proboscis, usually very short in the female, but long in the male and with tufts of long hairs in places (see

[1] Of course it may be argued that the odour of the female may be an adaptation to stimulate the male, such stimulation being necessary to the initiating of reproductive processes in the male. Such a contention would not invalidate the general argument, but merely shift the point of its application.

figs. 18–21). The rest of the mouth-parts compose the proboscis. The *mandibles* and *maxillae* are pairs of long, flattened, thread-like organs lying within the *proboscis sheath* and concerned with piercing the skin during biting. The proboscis sheath is formed by the *labium*, and has the form of a very much curved gutter or a tube not quite complete above, and does not enter the skin when the mosquito bites, but abuts against it, bending ventrally as the piercing mouth-parts are thrust deeper into the host. Almost at its tip it bears a pair of little lobed pieces—the *labella* (fig. 6) which project beyond the tip and serve to guide the piercing parts. The channel of the labium is closed above by a similar, but far more slender gutter open ventrally, called the *epipharynx*—an extension of the *labrum*. This terse description by no means exhausts the structure of the proboscis, nor explains the complex mechanism whereby the gnat simultaneously sucks blood from its host and injects into him saliva and whatever the saliva contains. Such description is beyond the scope of this work.

The *thorax* (fig. 6) bears the *wings*, the *halters* (vestigial hind-wings) and the *legs*, and is constricted posteriorly by a groove which cuts off a narrow, posterior strip—the *scutellum*. Projecting from the posterior end of the thorax, beneath the scutellum, and overhanging the first abdominal segment is a dome-shaped prominence—the *meta-notum*, or, better, the *postscutellum*.

The details of the wing-venation are shown in fig. 1. The vein forming the margin of the wing is called the *costal vein*; that immediately succeeding it, and meeting the costal vein about half-way between the base and tip of the wing, is called the *sub-costal* vein. Succeeding this, and running from the base nearly to the apex of the wing, is the *first longitudinal vein*. The *second longitudinal vein* branches from the posterior side of the first longitudinal vein, and forks into an anterior and a posterior branch near the tip of the wing. The *third longitudinal* vein rises from the second longitudinal vein, and runs unbranched to the margin of the wing between the posterior branch of the second and the anterior branch of the fourth longitudinal vein. That short part of it, from where it branches from the second vein to where it turns towards the margin, is called the *supernumerary cross-vein*. The *anterior*, or *mid cross-vein*, joins the end of the supernumerary cross-vein to the *fourth longitudinal vein*,

which rises near the base of the wing, and is divided into an anterior and posterior branch shortly before it reaches the margin. The *fifth longitudinal vein* also rises from near the base of the wing, and

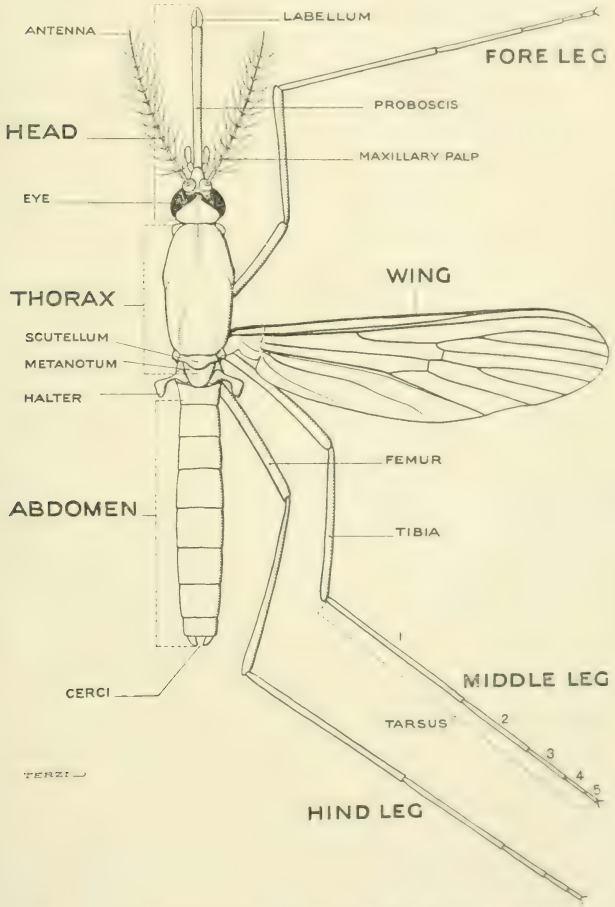


FIG. 6.—Generalised diagram of mosquito, to show the nomenclature of parts.

divides about half-way along its course into a curving anterior branch and a straighter posterior branch. A stout vein, the *posterior cross-vein*, joins the anterior branch of the fifth to the fourth longitudinal vein.

The legs (fig. 6) are divided into the following joints, namely from base to apex, the *coxa*, *trochanter* (a very short "corner" joint) *femur*, *tibia*, *tarsal joint* 1, *tarsal joint* 2, *tarsal joint* 3, *tarsal joint* 4, *tarsal joint* 5. Tarsal joint 1 is often, in fact generally, spoken of as the *metatarsus*; but I abandon this term as incongruous. The last tarsal joint ends in a pair of *ungues* or *claws*, which may or may not be toothed. The junction of the femur and tibia is the *knee*.

The abdomen consists of ten segments, but only the first eight are readily seen. The last two are modified for reproduction, and are more or less telescoped into the eighth segment. Generally, all that can be seen of them are the *cerci* of the *ovipositors* (fig. 6), borne on the tenth segment of the female, and consisting of a pair of short leaf-like projections; and, in the male, the great *forceps*, with their proximal joints or *side-pieces*, and their distal joints or *claspers* (see fig. 59), terminating in a *claw*. Smaller accessory organs, *harpes* and *harpagones*, occasionally are present, lying between the large forceps (see fig. 59).

2. THE LARVA (FIGS. 7–12).

The head of the larva bears several pairs of hairs, sometimes so arranged as to form transverse rows. On the upper surface of the head these hairs mostly occur on what is generally called the *clypeus*, a chitinous plate occupying the whole width of the head anteriorly, but narrowed posteriorly by two converging sutures, which separate the clypeus from lateral plates of chitin carrying the eyes, and in front of the eyes the antennae. These clypeal hairs are of great importance in *Anopheles*, and it is as well that their nomenclature should be straightened out. Typically, the clypeal hairs fall into four rows. The most anterior row is on the anterior edge of the clypeus, and consists of two pairs of hairs. These two pairs may be called the *inner anterior* pair and the *outer anterior* pair (fig. 7, *i.a.* and *o.a.*). They are present in *Anopheles* (fig. 7), and have been generally described simply as "clypeal hairs"; but they are absent in all other British genera. (A pair of short hairs occurs in front of the clypeal edge in both Anophelines and Culicines, and may be termed the

pre-clypeal pair (figs. 7, 8, 9, *pr.c.*). The second row consists of a single pair of *pre-antennal* hairs (figs. 7, 8, 9, *pr.a.*), lying, in *Anopheles* (fig. 7), just anterior to the level of the antennae, but rather indifferently placed in the Culicines (figs. 8, 9) with regard to this level. In Culicines, too, they are often extremely small and inconspicuous. The third row consists of three pairs of hairs, the *inner*, *mid*, and *outer post-antennal* pairs (figs. 7, 8, 9, *i.po.a.*, *m.po.a.*, *o.po.a.*), lying just posterior to the level of the antennae. The row tends to have a

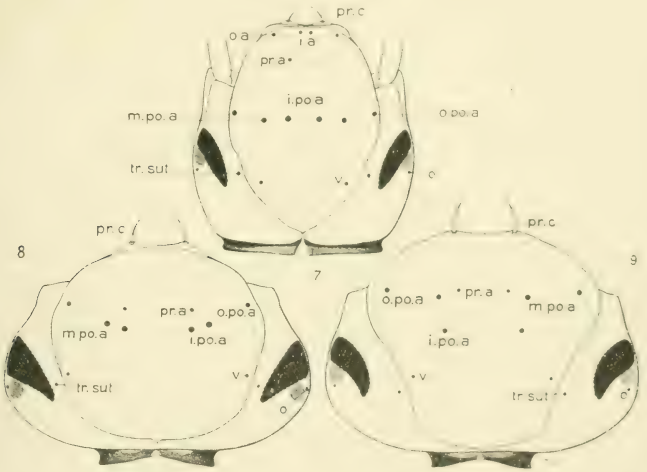


FIG. 7. — Distribution of hairs on head of *Anopheles* larva.

FIG. 8. — Distribution of hairs on head of *Theobaldia* larva.

FIG. 9. — Distribution of hairs on head of [illegible] larva.

posteriorly-directed curve. In *Ochlerotatus* (fig. 9), owing, apparently, to the forward and inward displacement of the mid post-antennal pair, the second and third rows are confused in arrangement, and the inner post-antennal pair lies nearly directly behind the mid post-antennal pair. In the first instar of *Ochlerotatus*—at least, in the species *nemorosus*, and in *Finlaya geniculata*, the mid post-antennal pair is in a line with the others. The mid post-antennal pair has a somewhat intermediate position in *Taeniorhynchus*, while in *Aëdes*, *Theobaldia* (fig. 8), *Culicella* and *Culex*, their position is normal. The fourth row

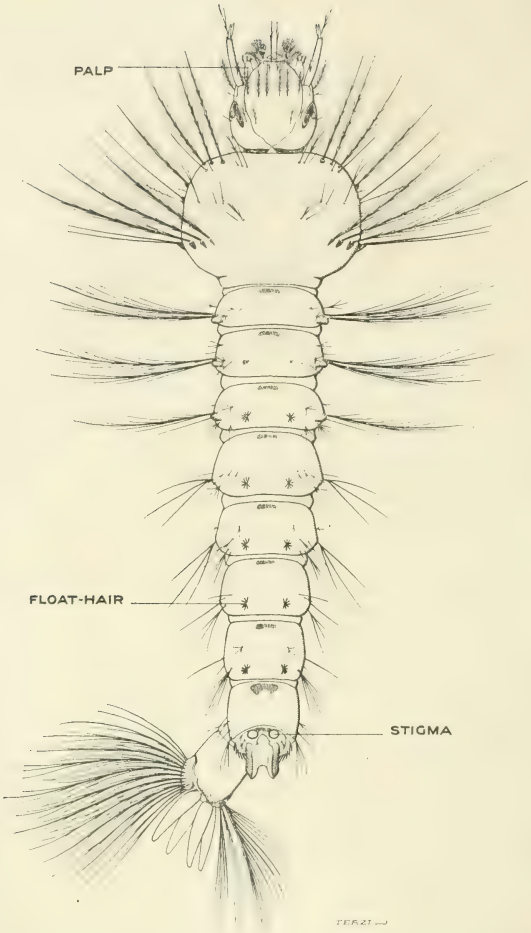


FIG. 10.—Larva of an Anopheline gnat (*i.e.*, of the genus *Anopheles*). Dorsal view. The ninth abdominal segment is twisted round so as to present a lateral view, to show the fin.

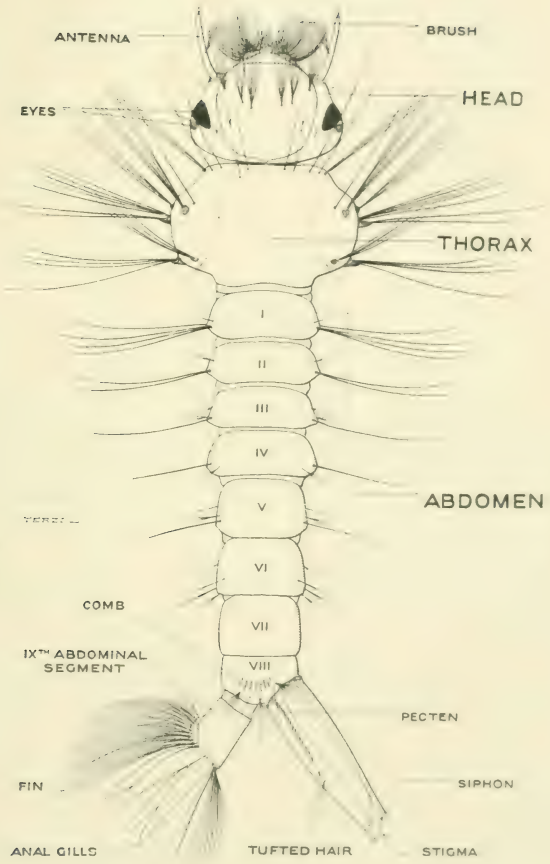


FIG. 11.—Larva of a Culicine gnat (*i.e.*, one of a genus other than *Anopheles*—the particular species figured is *Aedes aegypti*). Dorsal view. The eighth and ninth abdominal segments are twisted round so as to present a dorsal view to show the siphon, comb and fin.

consists of a single pair, the *vertical* hairs (figs. 7, 8, 9, *v*), which are always very small. In a row with them and just across the suture is another pair of very small hairs, which may be called the *trans-sutural* pair (figs. 7, 8, 9, *tr.s.*); while a third small hair, the *ocular* hair (figs. 7, 8, 9, *o*), lies in the neighbourhood of the eye. The hairs on the lower surface of the head have not been used to distinguish the species, and consequently are not described in detail.

On the head (figs. 10, 11, 12), laterally, is a pair of *antennae*, and

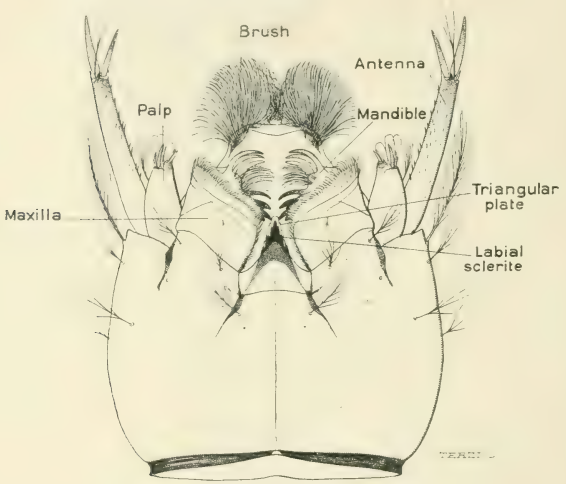


FIG. 12.—Ventral view of head of *Anopheles*.

posteriorly to these a pair of *eyes*. Each eye is divided by a constriction into a larger anterior portion and a smaller posterior portion, which may be completely detached. Ventrally and anteriorly (fig. 12) the head bears a pair of *brushes* on lateral lobes of the *labrum* called *flabellae*; a median lobe-like *palatum* also bears a tuft of hairs (omitted to save obscurity in fig. 12). In the middle of the ventral surface of the head are mouth-parts, of which the most prominent are the heavily-chitinised teeth of the *mandibles*, and the labial sclerite of the labium, against which the mandibles appear to bite. The *maxillae*

are more or less flat, inconspicuous organs with fringed edges. It is difficult to see that the *maxilliary palp* is connected with its maxilla; on the contrary, it appears at first sight to be an independent organ. It is often minute in Culicine larvae, but larger and somewhat prominent in Anophelines. The *labium* is a complex structure, consisting of four members placed one upon the other in dorsal-ventral sequence, like the leaves of a book. Ventral-most and outermost is a plain, wide, tongue-shaped chitinous flap, the *labial flap*. Next above this is a more or less triangular plate, feebly chitinised, with toothed free edges and often fringed with long hairs. Dorsal to this *triangular plate* is the heavily-chitinised *labial sclerite*, also triangular, and in shape very closely resembling a shark's tooth. Lying dorsal to the labial sclerite is the *labium* proper, a peculiar structure more or less shaped like a hollow cube, with the posterior and lateral faces represented only by a framework and the ventral face narrowed to a bar. On the dorsal and anterior faces are numerous chitinous teeth.

The thorax and abdomen (figs. 10 and 11) of the larva are characterised by numerous hairs of various shapes—simple, branched or tufted. The eighth abdominal segment bears a pair of stigmata dorsally, and laterally an arrangement of flattened hairs or scales called a *comb*. Each scale is posteriorly directed, fringed with minute cilia-like hairs, and often terminates in a stout spine or bristle. Primarily, the comb appears to consist of a dorsal-ventral row of flattened hairs or scales lying parallel with one another. In the Anophelines the scales retain their primitive parallel condition, but are united at their bases by a broad band of chitin so as to form a comb-like structure (figs. 83–85, 89–91, 95–97). Moreover, the band is continued dorsal-wards, and, passing posteriorly to the stigmata, is continuous with its fellow on the other side. A second comb-like structure, lying somewhat anteriorly and ventrally to the comb, is present in the first instar in *Anopheles* (figs. 100, 101, 101*a*). In most adult Culicines the primitive single row of parallel comb-teeth becomes broken up into a more or less confused group, though the teeth tend to remain parallel and directed posteriorly. *Finlaya geniculata*, however, and the first instar of those Culicines in which this stage is known, retain the primitive single-row arrangement of their comb-teeth.

In the Culicines the stigmata opening on the eighth segment are

carried up to the end of a long median projection called the *siphon* (fig. 11). This is heavily chitinised on the distal half only in the first instar, but throughout its length in succeeding instar. It carries one or more pairs of *tufted hairs* (simple in the first instar) ; and on each side, on its proximal half, a row of flattened toothed scales somewhat resembling those of the comb. Each of these rows is called a *pecten*, each scale composing it is a *pecten-tooth*, and each projection on a pecten-tooth is a *denticle*. The anus is situated at the end of the ninth abdominal segment, and is surrounded by four thin-walled papilliform processes, the *anal gills*. Ventrally, the ninth segment carries a series of tufted hairs arranged in an antero-posterior row approximately in a median plane, but actually alternately a little to left and right of the mid-line. They are inserted on chitinous transverse bars, which viewed from the ventral side of the larva have a gridiron-like aspect. Collectively, these median hair-tufts form a rudder-like *fin*, which probably steadies the floating larva by preventing a rocking motion, and adds power to a sweep of the tail for purposes of motion. In those forms in which the first instar has been observed this fin is absent, and its place is taken by simple posteriorly-directed appressed bristles.

II. IDENTIFICATION.

A. IMAGO.

1. TO DISTINGUISH THE SEXES.

In identifying British gnats it is necessary first to distinguish the sexes. When a specimen is secured, the question whether it is a male or a female must be determined before the following keys can be used.[1] Luckily, to determine the sex is a simple matter, for there are two easily-seen characters which afford infallible tests, namely, the structure of the antennae and the shape and appearance of the distal end of the abdomen.

[1] The keys for identification here used are founded upon those given by F. W. Edwards, 1912, The Entomologist, vol. xlv., pp. 191, 217, 260 ; moreover, further information given in these and other papers by the same author has been freely used, and much help has been rendered me by Mr. Edwards in correspondence and conversation, for which I take this opportunity of tendering him my best thanks.

In both sexes there are whorls of hairs on the greater part of the antennae, a whorl at each joint, except distally. But, while in the female the hairs forming these whorls are scanty, so that to the unaided eye the antennae are inconspicuous; in the male these whorls are so dense, and the hairs composing them so long, that the antenna as a whole appears as a thick plume, and the pair of antennae form, with the palps, the most conspicuous feature of the head. Figs. 13 and 14 show, respectively, the antennae of a male and a female gnat.

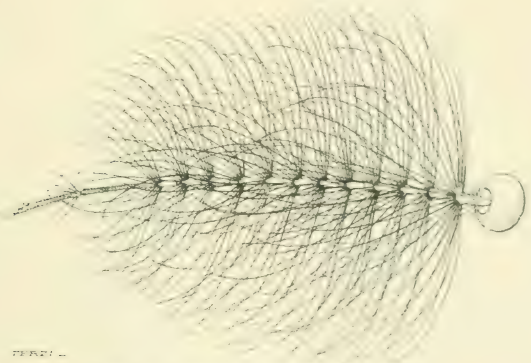


FIG. 13.—Antenna of male *A. (C.) cinereus*.

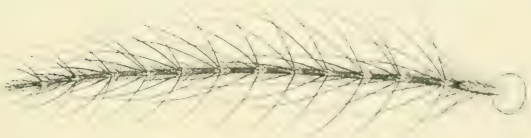


FIG. 14.—Antenna of female *A. (C.) cinereus*.

The abdomen of the male gnat (fig. 15) is, on the whole, club-shaped. It is somewhat narrower anteriorly, swells rather quickly towards the posterior end, begins to taper rapidly, and then is truncated. It terminates in a pair of rod-like bodies bearing many long and stiff hairs, and generally lying side by side, but sometimes somewhat diverging. These are the side-pieces of the forceps or

largest pair of clasping organs, and each bears distally and jointed with it a long thin bristle-like clasper, hardly visible to the naked eye, and generally bent at least at a right angle to the stout side-piece.

The abdomen of the female (fig. 16) is widest near the middle, tapers very slightly anteriorly, more decidedly in a posterior direction to more or less of a point, and ends in a pair of small leaf-like cerci, sometimes called ovipositors. Ventrally there is a median, lobed

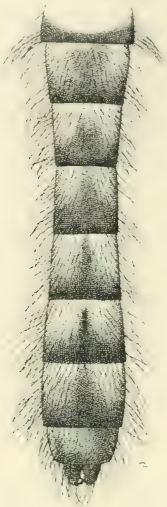


FIG. 15.— Abdomen of ♂ *Anopheles maculipennis.*

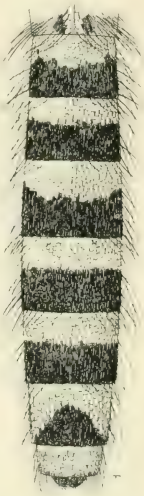


FIG. 16.— Abdomen of ♀ *Culex pipiens.*

unpaired piece. The ovipositors cannot be mistaken for the forceps of the male, being of a far smaller size as well as of a very different shape.

It should also be noted that in every British form, except *Aëdes cinereus*, the palps of the male are longer than the proboscis; and in every British genus, except *Anopheles*, those of the female are much shorter than the proboscis.

2. TO IDENTIFY THE GENERA.[1]

a. MALES.

When the sex of a specimen has been determined, it is possible to discover its genus by means of the following instructions. If the specimen is a male, the palps afford the greatest help for this determination. *Aëdes* is at once known by its palps which resemble those of female Culicines, being less than one-sixth the length of the proboscis (fig. 17). *Aëdes* may also be known by the wide distribution of broad, flat scales on the head (fig. 29). In most gnats the flat-lying (as opposed to the up-standing) scales on the head are nearly all narrow, the few broad ones being confined to the lower and posterior

FIG. 17.—Head of male *Aëdes cinereus*, from the side, to show the short palp.

parts of the sides of the head. In *Aëdes*, the broad scales invade the crown, and the narrow scales on the top of the head are confined to a median crest. This is so in both sexes.

In all British gnats other than *Aëdes*, the palps in the males are longer than proboscis, and, lying on each side of that organ, appear as feeler-like structures, thickly scaled, and with certain areas of their distal parts densely clothed with long, fine hairs. They are five-jointed, though the scaling and tufts of hair often obscure the boundaries of the joints. In *Anopheles* (fig. 18), the last two joints are short and thick, and together form a hairy head to the long slender stalk formed by the proximal joints. The whole palp somewhat resembles a golf-club. *Anopheles* is also distinguished from all

[1] The diagnostic characters do not necessarily hold outside the British species.

other British gnats by the abdomen (see fig. 15) which, except for numerous outstanding hairs, is naked, and has none of the scales which densely clothe the Culicine abdomen in both sexes (see fig. 16). The scutellum, too (see figs. 42, 43), is narrow, and not markedly trilobed as in Culicine genera (fig. 22).

FIG. 20.—Palp of male *Ochlerotatus caspius*. (Note: the palp of male *Toxorhynchus rutilus* is of this type.)

FIG. 18.—Palp of male *Anopheles maculipennis* (from above).

FIG. 19.—Palp of male *Culex pipiens* (side view).

FIG. 21.—Palp of male *Theobaldia annulata*. (Note: the palp of male *Culicella* is of this type.)

The male *Culex* has very distinctive and easily-distinguished palps (fig. 19). The terminal two joints, though hairy, are thin, taper distally, and are curved upwards through an angle of nearly 90°.

The remaining genera have palps very much alike. The last two joints are long compared with those of *Anopheles*, and do not turn

upwards through an angle of 90 like those of *Culex*. In *Orthopodomyia* the last joint is about as thick as, but only about a third as long as the last but one. In *Theobaldia* (fig. 21), and *Culicella* the last

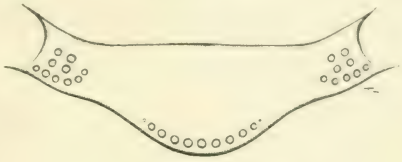


FIG. 22.—Scutellum of a Culicine gnat.

joint is somewhat thicker than the last but one, while in *Ochlerotatus* (except in *O. rusticus*), *Finlaya* and *Taeniorhynchus* it is slightly thinner (fig. 20). The hairs, however, render this difference somewhat

FIG. 23.—Male genitalia of *Culiseta annulata*.

obscure, and the genitalia are a more convincing guide. If the end of the abdomen is cut off, boiled for about five minutes in a fairly strong solution of caustic potash, placed on a microscope-slide, and the side-pieces separated with needles, even a fairly low-power lens will reveal

the remarkable difference in type between the genitalia of *Theobaldia*, *Culicella* and *Orthopodomyia* on the one hand (fig. 23), and *Ochlerotatus*, *Finlaya* and *Taeniorhynchus* on the other hand (figs. 59–66). *Theobaldia annulata* (the only British species of *Theobaldia*) may at once be known from *Culicella* and *Orthopodomyia* by having spotted wings; *Orthopodomyia albionensis* (fig. 130) is a black form with thin, white

FIG. 24.—Femur, tibia and tarsus of hind-leg of male *Taeniorhynchus richiardii*.

lines on the thorax; and *Taeniorhynchus richiardii* can be distinguished from *Ochlerotatus* by the first hind-tarsal joint which has a median pale band (fig. 24). In *Ochlerotatus*, too, both the claws of the fore- and mid-feet are toothed in both sexes; while in *Taeniorhynchus* the smaller claw on these feet is simple (figs. 25 and 26).

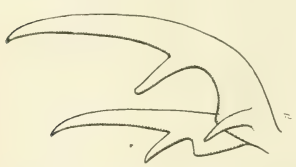


FIG. 25.—Claws on fore-foot of male *Ochlerotatus caspius*.

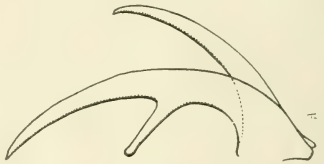


FIG. 26.—Claws on fore-foot of male *Taeniorhynchus richiardii*.

Finlaya geniculata, the only British species of the genus, differs from the British species of *Ochlerotatus* in the pattern of the abdominal segments. The light portions of the abdomen consist of a lateral pair of brilliant white triangular spots on each abdominal segment (fig. 58); while each segment in *Ochlerotatus* has a more or less complete pale band (figs. 51–57).

The following key summarises the generic differences detailed above :—

MALES.[1]

A. Abdomen without scales (fig. 15). Last two joints of the palps short, and together form the head of a club-shaped palp (fig. 18). Scutellum narrow and not markedly trilobed (figs. 42, 43) . . . . . I. *Anopheles*.

B. Abdomen densely clothed with flat imbricating scales (fig. 16). Scutellum wider and distinctly trilobed (fig. 22).

I. Palps not one-sixth the length of the proboscis (fig. 17). Flat-lying scales on the crown of the head nearly all wide (fig. 29) . . . . . II. *Aëdes*.

II. Palps about as long as the proboscis. Flat-lying scales on the crown of the head all narrow (fig. 28); wide scales confined to a few at the sides of the head posteriorly.

a. Last two joints of the palps tapering and upturned through an angle of nearly 90 degrees (fig. 19) . . . . VIII. *Culex*.

b. Last two joints of the palps not upturned.

1. Terminal joint of the palp slightly thicker than the last but one (fig. 21). Genitalia of male of the type shown in fig. 23.

α. Wings spotted. Posterior cross-vein nearly in a line with mid cross-vein (fig. 33). Second abdominal segment with a pale median stripe (fig. 36) . . VI. *Theobaldia*.

β. Wings plain. Posterior cross-vein, though near mid cross-vein, yet not nearly in a line with it (fig. 34). Second abdominal segment without a pale median stripe (fig. 37) . . . . . VII. *Culiseta*.

2. Terminal joint of the palp slightly thinner than the last but one (fig. 20), except in *Ochlerotatus rusticus*. Genitalia of male of the type shown in figs. 59–66.

a. Smaller claw on fore- and mid-feet simple (fig. 26). First hind-tarsal joint with median pale ring (fig. 24) V. *Taeniorhynchus*.

β. Both claws on fore- and mid-feet toothed (fig. 25). First hind-tarsal joint without median pale ring.

i. More or less complete, pale, abdominal bands; palps slightly longer than proboscis . . III. *Ochlerotatus*.

ii. Brilliant, white, triangular lateral abdominal spots (fig. 58); palps slightly shorter than proboscis . . . . . IV. *Finlaya*.

3. Terminal joint of the palp about as thick as, and only a third as long as the last but one. Genitalia of the type shown in fig. 23 . . . . . IX. *Orthopodomyia*.

(*O. albionensis* a black species with thin white lines on thorax.)

[1] See also characters of *Megarhinus* (*Toxorhynchites*) on p. 114.

b. Females.

To determine the genus of a female mosquito, the palps are not conspicuously useful, except in *Anopheles* and *Orthopodomyia*. The female *Anopheles* has bristle-like palps about as long as the proboscis (fig. 27), in *Orthopodomyia* (fig. 130) they are little more than a third as long, while in all the other female British Culicines the palps are not one-fourth as long as that organ (figs. 28, 29).

The females of *Aëdes*, *Ochlerotatus*, and *Finlaya* have long-tapering abdomens, and the first two have long cerci (figs. 51–58) ; while in the

Fig. 28.—Head of female *Ochlerotatus caspius*.

Fig. 27.—Head of female *Anopheles maculipennis*.

Fig. 29.—Head of female *Aëdes cinereus*.

female *Taeniorhynchus*, *Theobaldia*, *Culicella*, and *Culex*, the abdomen is blunt, and has short cerci (fig. 16). The claws of the fore- and mid-feet, too, are toothed in the three first-named genera (fig. 30) ; and those of the last four genera plain (fig. 31). As in the males of *Aëdes* and *Ochlerotatus*, the scaling of the head distinguishes also the females of these genera ; for broad, flat-lying scales nearly cover the crown in *Aëdes*, while in *Ochlerotatus* they are confined to small patches at the sides posteriorly (figs. 28, 29) ; and again, the brilliant, white, triangular, lateral, abdominal spots of *Finlaya geniculata* separate this species from the British species of *Ochlerotatus*, which have more

or less continuous pale abdominal bands (figs. 51–58). *Taeniorhynchus*, *Theobaldia*, and *Culicella* differ from *Culex* in the first hind-tarsal joint, which is shorter than the hind tibia (fig. 24), while in *Culex* it is about as long or longer (fig. 32).

The fork, too, of longitudinal vein 2 in *Culex* is decidedly long

FIG. 30.—Claws of fore-foot of *Ochlerotatus caspius* female.

FIG. 31.—Claws of fore-foot of female *Culicella morsitans*.

FIG. 32.—Hind-leg of *Culex pipiens*.

FIG. 33.—Distal part of wing of *Theobaldia annulata*.

and its stalk (that is, the part of the vein between the fork and the cross-veins) correspondingly short (fig. 1); while both fork and stalk of longitudinal vein 2 in *Taeniorhynchus*, *Theobaldia*, and *Culicella* are moderately long (fig. 33).

In *Theobaldia*, the cross-veins of the wing are nearly in a line

(fig. 33), the wings spotted, and the second abdominal segment has a median pale stripe (fig. 36); in *Culicella*, the posterior cross-vein is distant from the mid cross-vein not more than its own length (fig. 34), the wings are plain, and the second abdominal segment has no median pale stripe (fig. 37); while in *Taeniorhynchus* the posterior cross-vein

FIG. 34.—Cross-veins and parts of veins 2, 3, 4 and 5 in wing of *Culicella morsitans*.

FIG. 35.—Cross-veins and parts of veins 2, 3, 4 and 5 in wing of *Taeniorhynchus richiardii*.

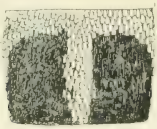


FIG. 36.—Second abdominal segment of female *Theobaldia annulata*.

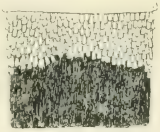


FIG. 37.—Second abdominal segment of female *Culicella morsitans*.

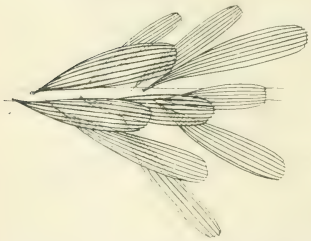


FIG. 38.—Scales from third longitudinal vein of wing of *Taeniorhynchus richiardii*.

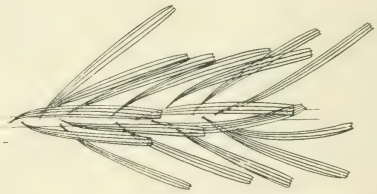


FIG. 39.—Scale from third longitudinal vein of wing of *Culicella morsitans*.

is distant at least its own length from the mid cross-vein (fig. 35), the wings are speckled with light and dark scales, and there is no median pale stripe. Besides, the wing-vein scales of *Taeniorhynchus* (especially the lateral wing-vein scales) are much wider than those of *Theobaldia* or *Culicella* (figs. 38, 39).

The following key summarises these female characters:

FEMALES.

A. Abdomen without scales (fig. 15). Scutellum narrow and not markedly trilobed (fig. 42). Palps nearly as long as the proboscis (fig. 27) . . . . . I. *Anophel*.

B. Abdomen densely clothed with imbricating scales (fig. 16). Scutellum markedly trilobed (fig. 22). Palps not one quarter the length of the proboscis (figs. 28, 29).

I. Abdomen long-tapering and pointed (figs. 51–58). Fore- and mid-feet with toothed claws (fig. 30).

a. Flat-lying scales on crown of head mostly broad . . II. *Ae*.

b. Flat-lying scales on crown of head all narrow.

i. More or less complete pale abdominal bands; cerci long III. *Ochlerotatus*.

ii. White, triangular, lateral abdominal spots; cerci short IV. *Finlaya*.

II. Abdomen slightly tapering and blunt (fig. 16). Fore- and mid-feet with untoothed claws (fig. 31).

a. First hind-tarsal joint shorter than the hind-tibia (fig. 24). Second longitudinal vein with moderately long stalk and fork (fig. 33).

1. Posterior cross-vein separated from mid cross-vein by at least its own length (fig. 35). Wings speckled with dark and light scales. Wing scales broad (fig. 38). Second segment of abdomen without pale median stripe . . . . . V. *Taeniorhynchus*.

2. Posterior cross-vein separated from mid cross-vein by less than its own length (fig. 34). Wings plain. Wing-scales narrow (fig. 39). Second segment of abdomen without pale median stripe (fig. 37) . . VII. *Culicella*.

3. Posterior cross-vein nearly in a line with mid cross-vein (fig. 33). Wings with spots. Wing-scales narrow. Second segment of abdomen with a median pale stripe (fig. 36) . . . . . VI. *Theobaldia*.

b. First hind-tarsal joint as long or longer than the hind-tibia (fig. 32). Second longitudinal vein with long fork and very short stalk (fig. 1) . . . . . VIII. *Culex*.

C. Abdomen and scutellum as in B. Palps a little more than one third the length of the proboscis (fig. 130) . . IX. *Orthopodomyia*.

In addition to the points above mentioned, a character at the distal end of the hind-tibia is sometimes useful in distinguishing the genera, and is applicable to both sexes. In *Ochlerotatus* and *Aedes*, for instance, there is a straight row of numerous bristles nearly at the apex of the hind-tibia. This is not apparent in *Culex*, *Culicella* and *Theobaldia*.

See also characters of [illegible] p. 112.

3. TO IDENTIFY THE SPECIES.

When the genus of a specimen has been determined, it is possible to go on to consider the particular species. There is only one British species in each of the genera *Aëdes*, *Taeniorhynchus*, *Finlaya*, *Theobaldia* and *Orthopodomyia*; so that these genera do not at present concern us. On the other hand, *Culicella* and *Culex* each have two; *Anopheles* three, and *Ochlerotatus* eight, British species; and each of these genera will now be dealt with in turn.

a. Anopheles.

Generally speaking, the three British species of *Anopheles* are easily distinguished, and it is only occasional specimens that give trouble. *A. maculipennis* is known at once by its spotted wings; and *A. plumbeus* is smaller and darker than *A. bifurcatus*, besides having a blackish thorax and ashy-grey streaks, instead of the brown thorax with pale streaks of *A. bifurcatus*. In some characters (*e.g.*, the breadth of the scales of the wings) *A. bifurcatus* is intermediate between *A. maculipennis* and *A. plumbeus*, so that doubtful specimens lie between *A. maculipennis* and *A. bifurcatus* on the one hand, and, on the other, between *A. bifurcatus* and *A. plumbeus*. Thus, the spots in *A. maculipennis* may be feebly developed, while the wing-scales of a specimen of *A. bifurcatus* may be particularly abundant, and tend to be massed at those parts of the wing where the aggregated scales of *A. maculipennis* form spots. (The same tendency may be observed in *Culicella morsitans* and *C. fumipennis*, thickly-scaled specimens of which show a tendency to a spotted condition, owing to the scales being more thickly crowded in places where in *Theobaldia annulata* they are aggregated to form spots.) Or a small, dark specimen of *Anopheles bifurcatus* may appear very much like *A. plumbeus*. It is useful, therefore, to notice one or two other points of difference between the three species of *Anopheles*.

1. In the middle of the anterior end of the thorax, on its upper surface, is a tuft of thin, hair-like scales. In *A. maculipennis* these are straw-coloured, very thin, and tend to be somewhat loosely distributed (fig. 40).[1] In *A. bifurcatus* and *A. plumbeus* they are decidedly whiter,

[1] In fig. 40 the scales are rather too closely aggregated.

broader, and more dènsely aggregated (fig. 41). In *A. plumbeus* they are even whiter in colour and broader than in *A. bifurcatus*; but the character of this scale-tuft is of more use in distinguishing *A. maculipennis* from *A. bifurcatus*, than *A. bifurcatus* from *A. plumbeus*.

2. The posterior outline of the scutellum of *A. maculipennis* and *A. bifurcatus* is a fairly regular curve, convex posteriorly (fig. 42). In

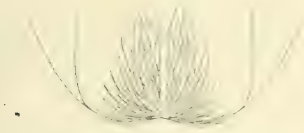


FIG. 40.—Fore-part of thorax of *Anopheles maculipennis*, viewed from above and in front.

FIG. 41.—Fore-part of thorax of *A. bifurcatus*, viewed from above and in front.

A. plumbeus it is somewhat flattened or even slightly concave at the sides (fig. 43). The whole scutellum is slighter in *A. plumbeus*, and the median tubercle smaller and more compact. In *A. maculipennis* the median tubercle is more diffuse and swollen than in *A. bifurcatus* and the lateral tubercles smaller. But the characters of the scutellum

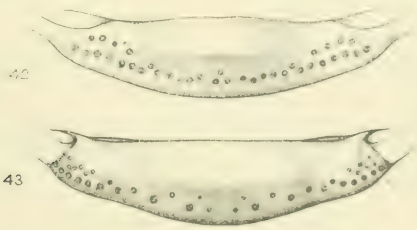


FIG. 42.—Scutellum of *Anopheles bifurcatus*.

FIG. 43.

are more useful in distinguishing *A. plumbeus* from *A. bifurcatus* than *A. bifurcatus* from *A. maculipennis*.

3. The male genitalia differ considerably in the three species, not only in the details of the smaller parts, but in the forceps themselves. If one of the stout basal joints or side-pieces of the forceps is isolated, besides the rather limp curved hairs with which especially

the distal end is plentifully provided, a single, straight, stiff bristle will be seen projecting from the inner edge of the side-piece; and a pair of stouter bristles arise from the ventral surface of the side-piece near its base. In *A. maculipennis* and *A. plumbeus* (figs. 44 and 46) the single bristle springs from near the middle of the inner side; and in *A. bifurcatus* (fig. 45) from near the apical end of the side-piece. In *A. maculipennis* the paired bristles (especially that on the inner side) are borne on a projection or lobe of the side-piece (fig. 44); in *A. plumbeus* they are inserted directly on the side-piece (fig. 46). In *A. bifurcatus* (fig. 45) the inner one is borne on a slight

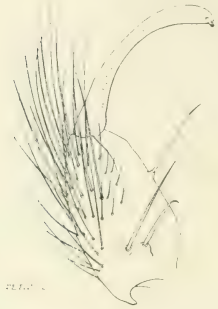


FIG. 44.—Left forceps of genitalia of *Anopheles maculipennis*, from beneath.

FIG. 45.—Left forceps of genitalia of *Anopheles bifurcatus*, from beneath.

FIG. 46.—Left forceps of genitalia of *Anopheles plumbeus*, from beneath.

projection, but the outer one is directly inserted; moreover, this outer bristle is double, flattened, and frayed distally into several branches.[1]

These differences may be tabulated as follows :—

Anopheles.

1. *Obvious Characters*—
   - A. Wings spotted . . . . . 1. *A. maculipennis.*
   - B. Wings plain.
     - I. Thorax brown, with pale longitudinal bands; larger species . . . . . 2. *A. bifurcatus.*
     - II. Thorax blackish, with ashy-grey longitudinal bands; smaller species . . . . . 3. *A. plumbeus.*

[1] This has been noticed and figured by S. R. Christophers, 1915, Indian Journal of Medical Research, vol. iii., p. 378, pl. xx., fig. 1. Christophers, following Felt, calls the paired bristles "claspettes."

2. *Less obvious Characters*—

A. Wing-scales less crowded and narrower; hair-like scales of thoracic tuft very narrow, less densely aggregated, and straw-coloured (fig. 40); posterior outline of scutellum forming an even curve; median tubercle of scutellum very diffuse and tumid; lateral tubercles small . . 1. *A. maculip[illegible]*

B. Wing-scales more crowded and less narrow; hair-like scales of thoracic tuft not so narrow, more densely aggregated, and white (fig. 41); posterior outline of scutellum forming an even curve (fig. 42); median tubercle of scutellum tumid, but not so diffuse as in *A. maculipennis*; and lateral tubercles larger . . . 2. *A. bif[illegible]*

C. Wing-scales more crowded and rather broad; hair-like scales of thoracic tuft broad, more densely aggregated, and white; posterior outline of the scutellum flattened, or even slightly concave, laterally (fig. 43); median and lateral tubercles small and well-defined . . . . 3. *A. plumb[illegible]*

3. *Characters of the Male Genitalia*—

A. Single bristle is near the apical end of the side-piece. The inner one of the paired bristles carried on a small projection; the outer inserted directly, double, flattened and much frayed distally (fig. 45) . . . . . 2. *A. bifurcatus.*

B. Single bristle is near the middle of the side-piece.

I. Paired bristles (especially the inner one) carried on projections or lobes of the side-piece (fig. 44) 1. *A. maculipennis.*

II. Paired bristles inserted directly on the side-piece (fig. 46) . . . . . 3. *A. plumbeus.*

b. Ochlerotatus.

The eight British species of *Ochlerotatus* fall readily (for purposes of identification) into two groups, one (figs. 47–50), including *O. caspius*, *O. curriei*, *O. vexans*, *O. waterhousei* and *O. annulipes*, having white bands on the hind-tarsal joints; and the other, represented by the species *O. detritus*, *O. nemorosus*, *O. rusticus*, having uniformly dark hind-tarsi. Apart from the white banding, the tarsi and legs generally in both groups may be speckled with light scales, giving a pepper-and-salt appearance to these structures; and the wings in both groups may have dark scales only or with but very few white scales (*O. vexans* in the first, and all except *O. detritus* in the second group), or may have mixed light and dark scales, so as generally to have a speckled look. The chief remaining characters for diagnosing the species are those exhibited by the abdominal patterns (figs. 51–57) and the male genitalia (figs. 59–65).

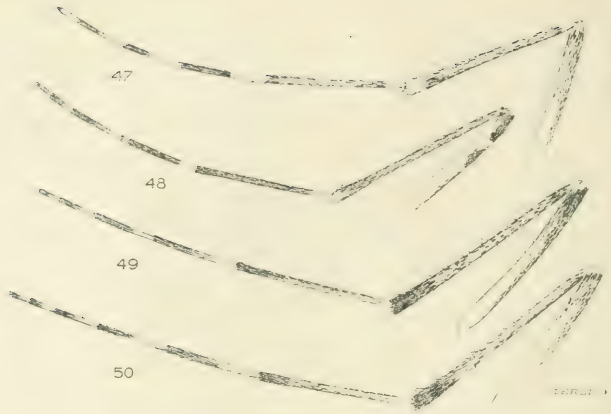


FIG. 47.—Right hind-leg of *O. caspius*.
FIG. 48.—Right hind-leg of *O. vexans*.
FIG. 49.—Right hind-leg of *O. waterhousei*.[1]
FIG. 50.—Right hind-leg of *O. annulipes*.

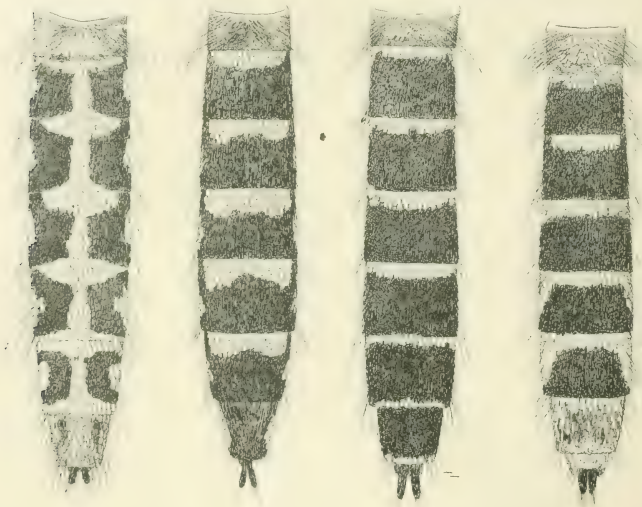


FIG. 51.—Abdomen of female *O. caspius*.
FIG. 52.—Abdomen of female *O. vexans*.
FIG. 53.—Abdomen of female *O. waterhousei*.
FIG. 54.—Abdomen of female *O. annulipes*.

[1] The sprinkling of dark scales on the proximal and ventral parts of the femur should be a little more pronounced in fig. 49.

In the first group, *O. caspius* and *O. curriei* are at once known by the white bands embracing the distal end of one tarsal joint and the proximal end of the next (fig. 47). In the other species the white band occupies only the proximal end of each joint. *O. caspius* is also easily recognised by the bright chestnut-orange colour of the thorax with whitish stripes, and by the same sharply-contrasted colours on the crown of the head. Thus, even a very much rubbed specimen may

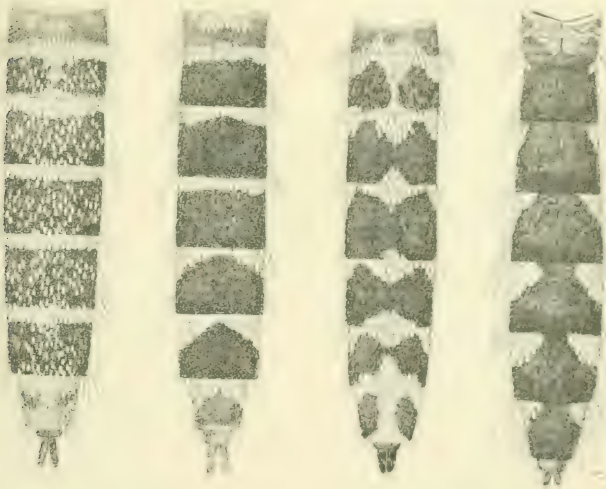


FIG. 55.—Abdomen of female *O. detritus*.

FIG. 56.—Abdomen of female *O. [illegible]*.

FIG. 57.—Abdomen of female *O. [illegible]*.

FIG. 58.—Abdomen of female *[illegible] cinereus*.

often be identified with certainty. *O. curriei*, on the other hand, has the top of the thorax dullish brown, with a pale band on each side. *O. caspius* has broad, mixed light and dark scales on the wings, and the male genitalia are shown in fig. 50, while *O. curriei* has narrower wing-scales, and the scales on longitudinal veins 3 and 5, and on the forks of 4, are mostly dark.

In *O. vexans* the white bands at the proximal ends of the tarsal joints are very narrow (fig. 48); while in *O. [illegible]* (fig. 49) and

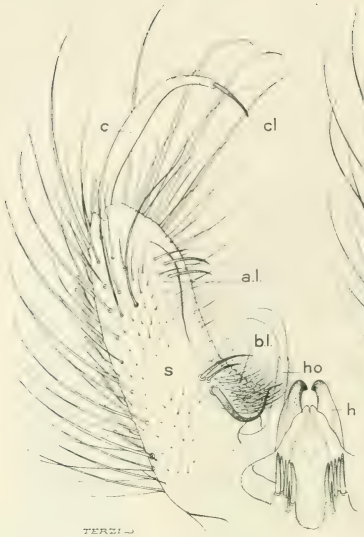


FIG. 59.—Genitalia of male *Ochlerotatus caspius*. a.l. Apical lobe. b.l. Basal lobe. c. Clasper. cl. Claw. h. Harpe. ho. Harpago. s. Side-piece.

FIG. 60.—Genitalia of male *O. vexans*. ho. Harpago.

FIG. 61.—Genitalia of male *O. waterhousei*.

FIG. 62.—Genitalia of male *O. annulipes*.

FIG. 63.—Genitalia of male *O. detritus*.

FIG. 64.—Genitalia of male *O. nemoro*[illegible]

FIG. 65.—Genitalia of male *O.* [illegible]

[illegible] of male [illegible]

O. annulipes (fig. 50) the bands of the last four tarsal joints are wide, occupying nearly half the joint in the latter, and about a third in the former species. *O. vexans*, too, has only dark scales on the wings, while the wings of the other two species have the pepper-and-salt appearance due to a mixture of light and dark scales. Its genitalia, too, have a remarkable form (fig. 60). Again, the undulating posterior border of the pale abdominal bands is characteristic of *O. vexans* (fig. 52).

O. waterhousei and *O. annulipes* are not so easy to distinguish. The males are best distinguished by the genitalia, which are markedly distinct (figs. 61 and 62). And there is a difference in the coloration of the thoracic scales of the females, though it is not easy of application (see F. W. Edwards, 1912, The Entomologist, vol. xlv., p. 194). In both, the ground-colour of the thoracic scaling is deep golden brown, and on this there are pale longitudinal markings of a brassy colour. In the females of *O. annulipes* the ground-colour is richer, and the lighter brassy lines yellower and brighter; so that the thorax of *O. annulipes* looks yellower and that of *O. waterhousei* browner. But the best general characters are in the hind-femur, and in the pattern beneath the abdominal segments. The outer surface of the hind-femur is fairly evenly sprinkled with dark scales in *O. waterhousei* (fig. 49), though proximally and ventrally they are not so numerous as distally and dorsally. The outer side of the hind-femur of *O. annulipes* is similar distally and dorsally, but proximally and ventrally it is almost destitute of dark scales (fig. 50). This difference is more pronounced in the females than in the males. On the underside of the abdomen of *O. annulipes* the dark markings form a continuous median stripe with slight lateral projections; while in *O. waterhousei* they form transverse stripes, and the median stripe is generally obscure or absent. The proboscis, also, in *O. annulipes* is yellow on the underside except at the base and tip; while in *O. waterhousei* it is merely pale.

In the second group *O. detritus* is unique for having mixed light and dark scales on the wings (figs. 67 and 68). Otherwise it very closely resembles *O. nemorosus* (which may have some white scales on the sub-costal vein), but there is generally a sprinkling of white scales on the dark portions of the abdomen above (fig. 55), and the

legs are more plentifully sprinkled with white scales than those of *O. nemorosus*; moreover, the male may be known by its genitalia (fig. 65).

In *O. detritus*, *O. nemorosus*, and *O. rusticus*, the abdomen is dark above, with more or less continuous transverse pale bands at the proximal end of each segment. As has already been observed, *O. detritus* may be known from the other two species by the pale scales on the wings as well as by the sprinkling of pale scales on the dark parts of the abdomen. *O. nemorosus* differs from *O. rusticus* chiefly in the paler, almost white tint of the abdominal bands, and their tendency to widen laterally rather than in the mid-line (fig. 60). In *O. rusticus*, the pale abdominal bands are yellower, and, in the female, tend to widen medianly to form a continuous line (fig. 57). In the male this median line appears only on the second segment. The male genitalia are shown in fig. 65; and even to the naked eye *O. rusticus* may be distinguished by the dense clothing of long hairs on the side-pieces.

FIG. 67.—Stalk of fork of second long. vein of *Ochlerotatus detritus*.

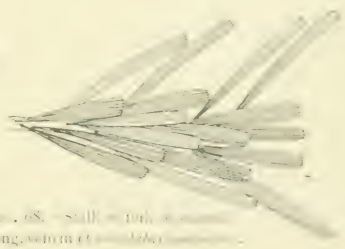


FIG. 68.—Stalk of fork of second long. vein of *Ochlerotatus rusticus*.

The following tables summarise these differences:—

Ochlerotatus.—General characters.

A. Hind-tarsi with pale bands.

- 1. Pale bands embrace ends of contiguous tarsal joints (fig. 47). Pale bands on abdomen overlap the junctions of the segments and are continuous with a median longitudinal band (fig. 51).
  - *a*. Wings speckled with broad, light and dark scales. Thorax bright chestnut-orange with pale longitudinal markings . . . . . *O. nigripes*
  - *b*. Wing scales narrower, wings speckled, but scales on third and fifth, and forks of fourth longitudinal veins chiefly dark; top of thorax brown in the middle and pale at the sides . . . . . *O. detritus*

II. Pale bands only at proximal ends of tarsal joints (figs. 48–50). Pale bands of abdomen chiefly at proximal ends of abdominal segments, and no median abdominal stripe (figs. 52–54).

a. Tarsal pale bands very narrow (fig. 48). Only dark scales on the wings . . . . . 3. *O. vexans.*

b. Tarsal pale bands occupying one third to half of each tarsal joint, except the first (figs. 49, 50). Wings speckled with light and dark scales.

1. Outer side of hind-femur sprinkled with black scales on the proximal and ventral part (fig. 49). Pale markings on thorax whitish in female. Basal lobe of side-piece in male with a tuft of strong bristles basally, and a long, hairy, lobe-like basal extension (fig. 61). Proboscis in both sexes pale beneath in the middle . . . . . 4. *O. waterhousei.*

2. Outer side of hind-femur without black scales on the proximal and ventral part (fig. 50). Pale markings on thorax of female bright yellowish. Basal lobe of side-piece in male without a tuft of strong bristles, and without a long, hairy lobe-like extension fig. 62). Proboscis of both sexes yellow beneath in the middle . . . . . 5. *O. annulipes.*

B. Hind-tarsi entirely dark.

I. Wings speckled with light and dark scales (fig. 67). Dark portions of abdominal segments sprinkled with white scales (fig. 55) . . . . . 6. *O. detritus.*

II. Wings with dark scales only (fig. 68)—a few light scales on the sub-costal vein in *O. nemorosus*—

a. Abdominal bands whitish, widening laterally, but not medianly (fig. 56) . . . . . 7. *O. nemorosus.*

b. Abdominal bands yellowish, widening medianly in the female, so as to tend to form a pale median line fig. 57). In the male a median line only on segment 2. The genitalia are very hairy (fig. 65) . . . 8. *O. rusticus.*

2. *Ochlerotatus* and *Finlaya*.—Male genitalia (figs. 59–66).

The most obvious structures of the male genitalia of *Ochlerotatus* are the proximal joints of the outermost pair of grasping organs, or *forceps*. Each of these large proximal joints, or *side-pieces* (fig. 59, *s.*) has hinged to its distal end a more or less slender hook, the *clasper* (fig. 59, *c.*), which itself is terminated by a thin *claw* (fig. 59, *cl.*). On the inner side, each side-piece is more or less divided longitudinally into a *dorsal* and ventral *flap*. The dorsal flap generally has a more or less straight edge, but the ventral flap generally has pronounced *apical* (fig. 59, *a.l.*) and *basal lobes* (fig. 59, *b.l.*). The apical lobe is

KEY TO MALE GENITALIA IN BRITISH SPECIES OF *Odontosia* AND *Pygaera*.

A. Clasper much flattened and becoming wider distally; apical lobe very small; basal lobe very wide and projecting but little. Harpago with somewhat globular apex . . 3. *O. carmelita* (fig. 71).

B. Clasper narrow and tapering distally; apical joint of harpago more or less strap-shaped or expanded, but never globular.

I. Outer and inner edges of side-pieces nearly parallel, and strongly and regularly curved, the whole side-piece being narrow and forming the arc of a circle; apical lobe of ventral flap hardly existent; only the distal part of the basal lobe developed, and this is prolonged into a narrow arm-like projection with expanded hand-like end; the bristles of the tuft at the base of the basal lobe are exceedingly long, and extend along the edge of the ventral flap as a dense fringe of very long hairs; claw of clasper undulating; distal joint of harpago spatulate . . 8. *O. rusticula* (fig. 65).

II. Outer edge of side-piece nearly straight or slightly curved; inner edge of dorsal flap more or less undulating; lobes of ventral flap variously developed.

a. Apical lobe of ventral flap very slightly developed; distal joint of harpago strap-shaped.

1. Basal lobe of ventral flap projecting abruptly and bearing a few specially large bristles basally; three small notches on outer side, and one on inner side of clasper, near its tip—a hair springs from each . 1. *O. caspana* (fig. 59).

2. Basal lobe of ventral flap forming but a slight, rounded prominence, and has no specially large basal hairs; clasper without any hair-bearing notches near its tip, or with but one . . . . 9. *Finlaya geniculata* (fig. 66).

b. Apical lobe of ventral flap prominently developed, even if small; basal lobe abruptly prominent.

1. Basal lobe carried on a broad base; near the tip of the clasper, and on its outside, four or five little hair-bearing notches—on the inside, none; distal joint of harpago strap-shaped; one large bristle at base of basal lobe . . . . . 7. *O. notha* (fig. 74).

2. Basal lobe, if prominent, carried on a comparatively narrow base and more or less conical in shape.

a. Edge of dorsal flap sharply undulating; basal lobe not prominent, and not distally produced; distal joint of harpago flattened, about twice as long as wide, with a rather narrow, delicate, rounded, selvedge-like expansion . . . 5. *O. anmulipes* (fig. 62).

β. Edge of dorsal flap nearly straight; basal lobe with a prominent tuft of long bristles, and distally drawn out into a spatulate expansion; distal joint of harpago not much flattened, but with a very delicate flag-like expansion on one side . . 4. *O. wardlei* (fig. 61).

γ. Edge of dorsal flap nearly straight; a few extra-large bristles at proximal end of the basal lobe; no apical extension of basal lobe, distal joint of harpago strap-shaped . . . . 6. *O. curvata* (fig. 63).

generally covered with short, small hairs ; but the basal lobe, as a rule, has a tuft of long, stiff bristles at its base, and, distally, is covered with little mammilliform projections, each of which bears a small, but stiff, hair. The dorsal flap of the side-piece is covered with very long coarse hairs, and often with a fair sprinkling of scales.

Between the side-pieces, and about a half as long as them, is another pair of hook-like structures, the *harpagones*[1] (fig. 59, 60 *ho*). Each harpago has a rod-like, more or less curved, basal joint, and a limp, hook-like, distal joint, which may be much flattened or expanded. A third and fourth pair of hook-like organs, the *harpes* (fig. 59, *h*) and *unci* lie within the harpagones. Each harpe is more basally placed than the corresponding harpago of each side, and consequently, though nearly as long, does not project nearly as far. Their shape varies but little in *Ochlerotatus*.

FIG. 69.—Proboscis of female *Culicella morsitans*.

FIG. 70.—Proboscis of female *Culicella fumipennis*.

c. Culicella.

Culicella morsitans and *C. fumipennis* are nearly alike ; in fact, the flies of the two species are very difficult to distinguish in both sexes. The larvae, however, are quite distinct. The proboscis in both species is black, but the female of *C. fumipennis* has a few white scales on the proboscis, especially at the sides (figs. 69 and 70).[2] The males may be distinguished by the comparative length of the first fore-tarsal joint and the remaining four joints. In *C. morsitans* the first fore-tarsal joint is decidedly longer than the remaining four joints, while in *C. fumipennis* it is about as long. (See F. W. Edwards, 1912, The Entomologist, vol. xlv., pp. 261–2.) In practice, however, I have

[1] These structures have often been termed "harpes" in descriptions, and *vice versa*, the harpes have been termed "harpagones."

[2] These differences are somewhat exaggerated in the figures.

found this test hard of application, owing to the difficulty of ensuring no fore-shortening of these structures in viewing them. The lower side of the abdomen of both sexes also presents a differen[illegible] In *fumipennis* (fig. 72) the lower side of the more distal segments of the abdomen, especially segments six and seven, have a well-defined pattern of darker scales upon a light background. The lighter scales form a pair of triangular patches at the base of the segment, and there is a median triangular patch at the apex of the segment. In *morsitans* (fig. 71) the lighter scales are scattered more irregularly over the segment beneath, and there is only a tendency to the pattern formed in *C. fumipennis*.[1] This is specially marked in segment six.

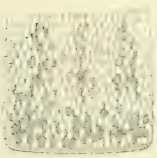


FIG. 71.—Under-side of sixth abdominal segment of male *Culicella morsitans*.

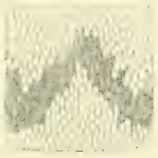


FIG. 72.—Underside of sixth abdominal segment of male *Culicella fumipennis*.

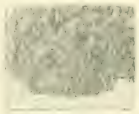


FIG. 73—[illegible] female [illegible].

KEY TO THE GENUS *Culicella*.

A. In female, proboscis black (fig. 69) with no (or possibly one or two) white scales at sides. In male, first fore-tarsal joint decidedly longer than the remaining four joints; segments four to seven of the abdomen (especially segment six) beneath with a diffuse pattern, chiefly of lighter scales (fig. 71). [illegible]

B. In female, proboscis black with a few white scales at the sides (fig. 70). In male, first fore-tarsal joint is hardly longer than the remaining four joints; segments six and seven of the abdomen (especially segment six) beneath with a clear pattern of lighter and darker scales (fig. 72) . . . . *C. fumipennis*

d. Culex

Only one specimen of *Culex apicalis* has been taken in Britain. But since this is an authentic capture (the specimen is in the museum of Cambridge University), and there are no obvious circumstances pointing to its introduction, the species must be regarded as British, and a comparison made with *Culex pipiens*, the Common Gnat.

[1] These differences are somewhat exaggerated in the figures.

The transverse pale bands on the abdomen of *Culex pipiens* are basal (fig. 16), while those of *C. apicalis* are apical (fig. 73). They are cream-coloured in *C. pipiens* and whitish in *C. apicalis*. The general coloration of *C. pipiens* is a rich golden brown, while that of *C. apicalis* is a very dark grey. It is hardly necessary to put these three diagnostic characters in a tabular form.

B. THE LARVA.

1. TO IDENTIFY THE GENERA.[1]

It is not possible in the present state of our knowledge to make a complete scheme for the identification of the pupae of British Mosquitoes. Doubtless in time this could be accomplished, and already some distinctions have been published (*e.g.*, F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. i., pp. 51–2). But generally the differences are not readily seen, and often would be extremely minute. Moreover, for the practical purposes of identification, there is comparatively little loss in being unable to identify a pupa. For where pupae are found, larvae, as a rule, are also abundant; and, since the pupal instar persists but a few days, it is often possible to keep the pupa and thus rear the fly. The distinctions, therefore, of the larvae will be next considered.

Anopheles-larvae may at once be known by the absence of a siphon (figs. 10 and 11). Their tracheae open by a pair of spiracles, or stigmata dorsally placed on the eighth segment, and nearly flush with the general surface. In all the other genera—called collectively Culicines —the spiracles are borne on the end of a long, straight, horn-like prominence of the eighth segment, the siphon, heavily chitinised in all instar except the first. When a larva is at rest just beneath the surface-film, the horizontal position distinguishes *Anopheles* from a Culicine; the latter hangs from the surface by its siphon at an angle of about 45 degrees. When disturbed, *Anopheles*-larvae jerk themselves backwards with great swiftness, and slowly sink; while Culicine larvae jerkily wriggle directly towards the bottom.

Taeniorhynchus has a siphon curiously modified for piercing the stems of aquatic plants. It is wide proximally, but suddenly narrows into a long tapering point. There is no pecten (fig. 74).

[1] The diagnostic characters do not necessarily hold outside British species.

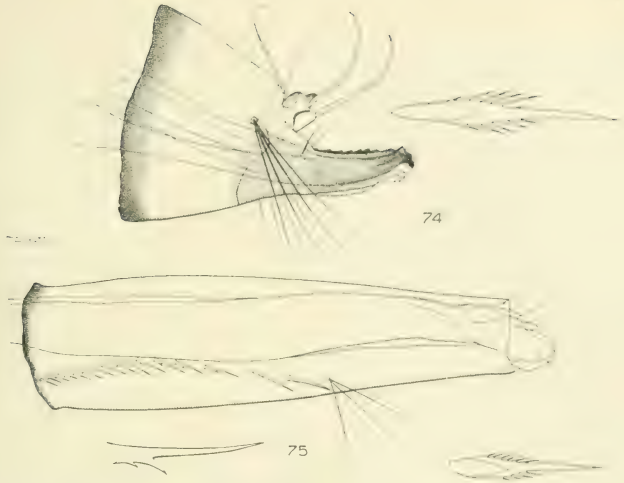


FIG. 74.—Siphon of *Taeniorhynchus richiardii*. FIG. 75.—Siphon of *A*

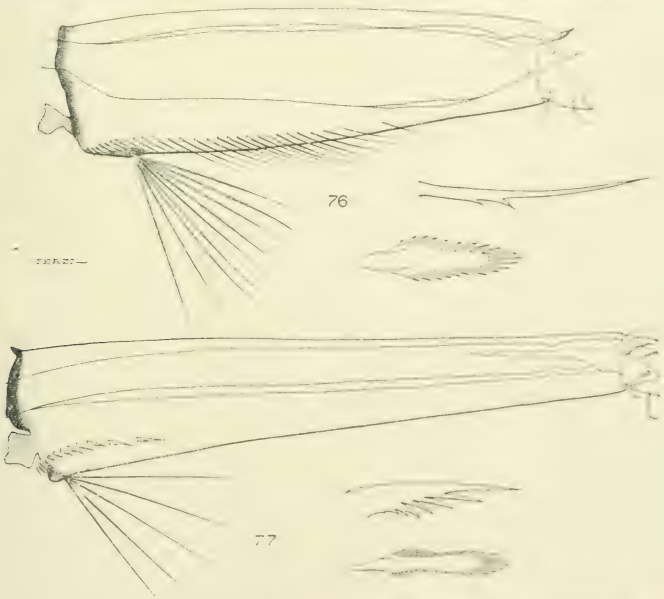


FIG. 76.—Siphon of *Theobaldia annulata*. FIG. 77.—Siphon of

Orthopodomyia has a normal siphon, but no pecten (fig. 132, p. 111).

Aëdes, *Ochlerotatus*, *Finlaya*, *Theobaldia*, and *Culicella* have a single pair of tufted hairs on the siphon (*Ochlerotatus rusticus* has a second

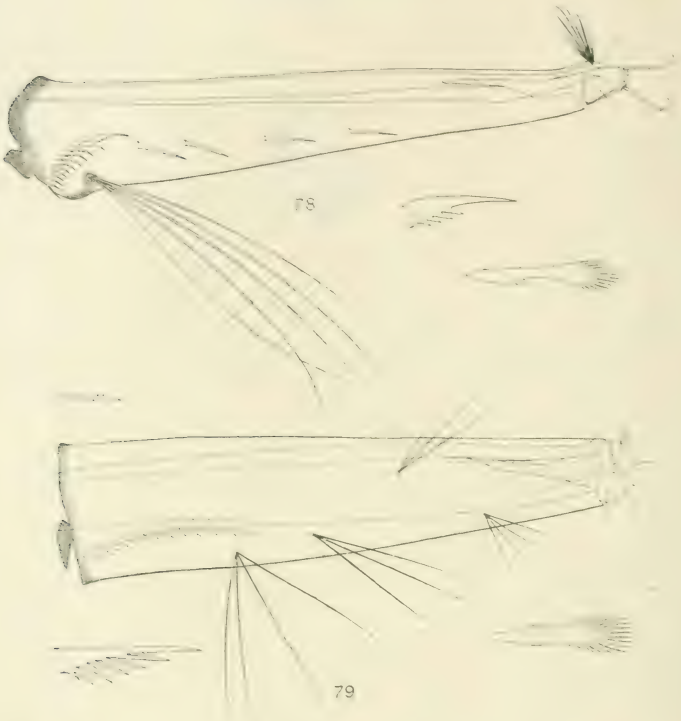


FIG. 78.—Siphon of *Culex fatigans*. FIG. 79.—Siphon of *Culex pipiens*.

minute tufted hair), while *Culex* (fig. 79) has several such hairs in scattered positions on the very slender siphon.

In *Aëdes* (fig. 75) the siphon is comparatively slender, nearly four times as long as wide; the pecten extends to about the middle of the siphon, and the few most distal teeth are separated by wide gaps.

The tufted hair lies in a line with the pecten, between the last tooth and the distal end of the siphon, and, consequently, considerably beyond the middle of the siphon. The scales of the comb lie in a transverse line.

In *Ochlerotatus* and *Finlaya* (figs. 105–122) the siphon is comparatively stout, not more than thrice as long as wide; the pecten does not extend as far as the middle of the siphon, except in *O. varipes* and *O. rusticus*; and the tufted hair lies near the distal end of the pecten, either in a line with it or just ventral to it. The antennae of the larval *Finlaya* are without the appressed spines that are scattered over the antennae in *Ochlerotatus* (fig. 104).

In *Theobaldia* (fig. 76) and *Culicella* (figs. 77–8) the tufted hair lies ventral to the pecten near its proximal end. In *Theobaldia* the siphon is stout, and the pecten-teeth end in long hair-like threads. In *Culicella* the siphon is very slender and the pecten-teeth normal.

In addition to the above characters, Mr. F. W. Edwards has pointed out to me that the hairs of the second pair above the anus are tufted in the genera *Taeniorhynchus*, *Theobaldia*, and *Culicella*, like those of the first pair; but simple in *Aëdes*, *Ochlerotatus*, and *Finlaya*. In *Culex* they are bifid.

KEY TO GENERA OF LARVAE.

A. Siphon absent (fig. 10 . . . . . I. *Anopheles*.

B. Siphon present.

I. Pecten absent. Siphon short with wide base and pointed apex (fig. 74) . . . . . V. *Taeniorhynchus*.

II. Pecten present. Siphon more or less cylindrical, tapering somewhat distally.

a. Siphon with a single pair of tufted hairs (a second minute pair in *Ochlerotatus rusticus*), or of simple hairs in the first instar.

1. Tufted hair near the distal end of the pecten.

α. Siphon slender; tufted hair well beyond the middle of the siphon; pecten extending to about the middle of the siphon; the last few pecten-teeth strongly spaced (fig. 75) . . . . . II. *Theobaldia*.

β. Siphon stout; tufted hair generally near the middle of the siphon, and the pecten not extending to the middle: if the tufted hair is decidedly beyond the middle, the last few pecten-teeth are not especially widely spaced (fig. 105) . . . . . III. *Ochlerotatus*.

2. i. Antennae with scattered appressed spines . . . III. *Ochlerotatus*.

ii. Antennae without scattered appressed spines (fig. 0 . . IV. *Culicella*.

2. Tufted hair near the proximal end of the pecten, or about at the middle of the pecten in the first larval instar.
   - *a*. Siphon stout; pecten-teeth drawn out terminally into long hair-like filaments (fig. 76) . . . . . VI. *Theobaldia*.
   - *β*. Siphon slender; pecten-teeth normal (figs. 77–78) . VII. *Culicella*.

Siphon with several pairs of tufted hairs (of simple hairs in the first instar) (figs. 79, 126–8) . . . . . VIII. *Culex*.

III. Pecten absent. Siphon as in II. In fourth instar, abdominal segments 7 and 8 with heavily chitinised dorsal plates (fig. 132) . . . . . IX. *Orthopodomyia*.

2. TO IDENTIFY THE DIFFERENT SPECIES AND (AS FAR AS THEY ARE KNOWN) THE DIFFERENT INSTAR OF EACH SPECIES.

a. Anopheles.

a. The Fourth (last) Larval Instar.

In *A. maculipennis* and *A. bifurcatus* (figs. 80, 81) the six post-antennal hairs are large and pinnately branched, while in *A. plumbeus* (fig. 82) they are very small, and simple. In *A. plumbeus* the anterior clypeal hairs are simple, or nearly so. In *A. bifurcatus* they are simple, or, at most, split at the ends into two or three branches. In *A. maculipennis*, the outer hair, lying over the brush, is branched repeatedly, while the inner hair has a few branches arranged pinnately.

The palp in all three species bears a branched hair near the apex, apically and internally a pair of small, sub-equal spines, and apically and externally a second pair of spines, which in *A. plumbeus* are sub-equal, but unequal in the other two species, especially in *A. bifurcatus*. The apex of the palp also bears three chitinous laminae, which are very thin and exceedingly difficult to see at their distal ends.

The float-hairs of *A. maculipennis* have about twenty-two leaflets, with their bases arranged on an elongate capitulum, which is sessile or with a short, thick stalk. In *A. bifurcatus* the leaflets are about sixteen in number, and are inserted on a more club-shaped capitulum with a more slender stalk. In *A. plumbeus* about fourteen leaflets are crowded at the apical end of a club-shaped capitulum with a rather thick stalk.

The antenna of *A. maculipennis* and *A. bifurcatus* has a branched hair towards the base in the former, and near the base in the latter

species. In *A. plumbeus* this hair is simple, and nearer the middle of the antenna which is short and has no scattered hairs (figs. 80–82).

The comb of *A. maculipennis* (fig. 83) has about twenty-six to

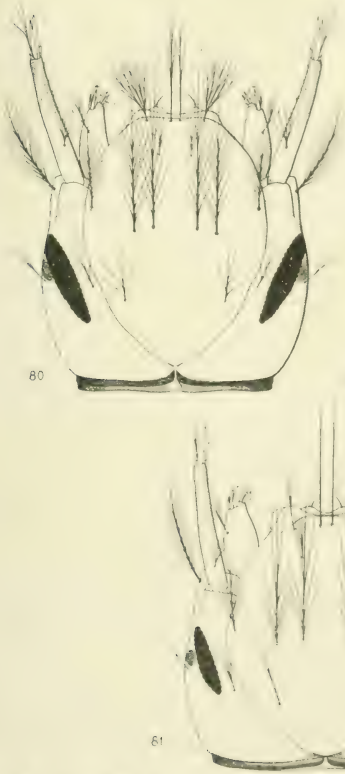


Fig. 80.—Head of fourth larval instar of *A. maculipennis*.

Fig. 81.—Head of fourth larval instar of *A. punctipennis*.

Fig. 82.—Head of fourth larval instar of *A. plumbeus*.

thirty teeth of at least three sizes; about seven large, and between each of these one or two of medium size, and between each medium-

sized tooth one or two small teeth. In *A. bifurcatus* (fig. 84) the comb has about twenty to twenty-five teeth in all, of which about ten are large, and between each of these one or two smaller teeth. But the difference in size between the larger and smaller teeth of *A. bifurcatus* is less than that between the larger and medium teeth of *A. maculipennis*. In *A. plumbeus* (fig. 85) the comb consists of about sixteen teeth, most of which are large, but a few slightly smaller ones occasionally occur.

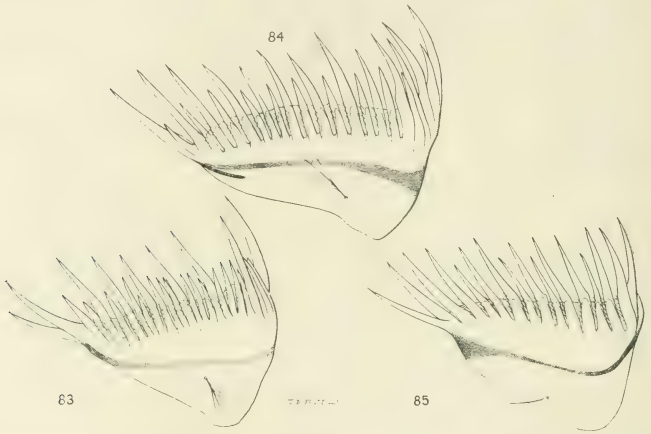


FIG. 83.—Comb of fourth larval instar of *A. maculipennis*.

FIG. 84.—Comb of fourth larval instar of *A. bifurcatus*.

FIG. 85.—Comb of fourth larval instar of *A. plumbeus*.

β. THE THIRD LARVAL INSTAR.

The differences between the three species shown by the anterior clypeal and post-antennal hairs are the same in the third larval instar, except that in *A. plumbeus* the anterior hairs are more branched than in the fourth instar (figs. 86, 87, 88).

The palps of the third larval instar resemble those of the fourth instar, but the hair towards the apex of the palp of the third instar, *A. plumbeus*, is simple, or almost so.

The float-hairs of the third larval instar show differences similar to

those of the fourth instar, but they have fewer leaflets throughout than those of the fourth larval instar.

The antennae of the third instar are similar to those of the fourth instar.

The comb of the third instar, *A. maculipennis*, has about sixteen teeth in all; generally seven larger teeth, and between them one or two considerably smaller teeth, which, however, vary somewhat in

Fig. 86.—Head of third larval instar of *A. maculipennis*.

Fig. 88.—Head of third larval instar of *A. plumbeus*.

Fig. 87.—Head of third larval instar of *A.* [illegible].

size (fig. 89). In *A. bifurcatus* there are about eighteen teeth; eight or ten large teeth, and between them an occasional and somewhat smaller one (fig. 90). In *A. plumbeus*, the comb consists of about twelve sub-equal teeth (fig. 91).

γ. The Second Larval Instar.

The second larval instar in all three species may be known from the third and fourth by the palp, which has no sub-apical hair. The

hairs of the head present the same difference between the three species as those of the third instar, but the inner clypeal hair of *A. plumbeus* is more branched, and the outer is twice-forked (figs. 92, 93, 94). The frontal hairs present the same difference, but have fewer

FIG. 92.—Head of third larval instar of *A. maculipennis*.

FIG. 93.—Head of third larval instar of *A. bifurcatus*.

FIG. 94.—Head of third larval instar of *A. plumbeus*.

branches. The comb of *A. maculipennis* has six or seven large teeth, and one or occasionally two smaller teeth between each large one (fig. 95). In *A. bifurcatus* there are also six or seven larger teeth alternating with

FIG. 95.—Head of second larval instar of *A. maculipennis*.

FIG. 96.—Head of second larval instar of *A. bifurcatus*.

FIG. 97.—Head of second larval instar of *A. plumbeus*.

as many smaller ones; but, as before, the difference in the size of the teeth is less marked than it is in *A. maculipennis* (see fig. 96). In *A. plumbeus* there are about ten sub-equal teeth (fig. 97).

δ. The First Larval Instar.

The first larval instar of *A. maculipennis*, *A. bifurcatus*, and *A. plumbeus* so closely resemble one another that they are not easy to distinguish. In all three species the first differs very considerably from the second instar. All hairs of the head above are simple, except that one or more of the post-antennal hairs may be forked in the first

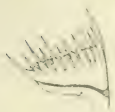


Fig. 95.—Comb of second larval instar of *A. maculipennis*.

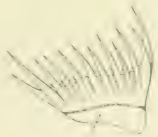


Fig. 96.—Comb of second larval instar of *A. bifurcatus*.

Fig. 97.—Comb of second larval instar of *A. plumbeus*.

two species; in some specimens of *A. maculipennis* one or both of the outer anterior pair is forked (figs. 98, 99); and in *A. plumbeus* all the anterior clypeal hairs are more or less branched (fig. 99a). The float-hairs have but a single leaflet. The comb (figs. 100, 101, 101a) has no alternation of teeth of different sizes, though they graduate somewhat in size from the middle towards the dorsal end, and considerably

Fig. 98. Head of first larval instar of *A. maculipennis*.

Fig. 99. Head of first larval instar of *A. bifurcatus*.

Fig. 99a. Head of first larval instar of *A. plumbeus*.

from the middle towards the ventral end. The number of teeth varies considerably in different specimens, so that in any individual it is not safe to use the number as diagnostic of the species; but generally there are six in *A. maculipennis* and eight in *A. bifurcatus*, but vary from five to nine in *A. maculipennis* and from eight to ten in *A. bifurcatus*; and there are about seven in *A. plumbeus*. There is a

[1] The large [illegible] plumose hair lying [illegible] the antenna has been [illegible] omitted.

second comb-like arrangement of teeth lying rather anterior and ventral to the primary comb. There are generally five teeth in this secondary comb, but the number varies considerably in different individuals. One or two of the teeth are often of a minute size compared with the rest, which are approximately equal in size

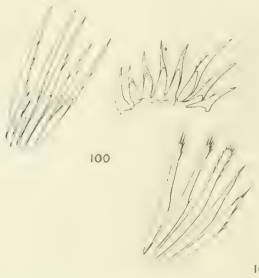


FIG. 100.—Primary and secondary comb of first larval instar of *A. maculipennis*.

FIG. 101.—Primary and secondary comb of first larval instar of *A. bifurcatus*.

FIG. 101a.—Primary and secondary comb of first larval instar of *A. plumbeus*.

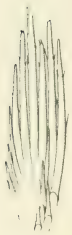


FIG. 102.—Appressed bristles on ventral surface of ninth abdominal segment of first larval instar of *A. maculipennis*.

FIG. 103.—Appressed bristles on ventral surface of ninth abdominal segment of first larval instar of *A. bifurcatus*.

FIG. 103a.—Appressed bristles on ventral surface of ninth abdominal segment of first larval instar of *A. plumbeus*.

(figs. 100–101a). A good character (besides the sub-antennal hair) for the first instar of the three species is that of the appressed bristles that lie on the ventral side of the ninth (last) abdominal segment; they form a wider group, and there are four or five larger

pairs in *A. bifurcatus*; while in *A. maculipennis* they form a narrower group, and there are only about three larger pairs (figs. 102–103); and in *A. plumbeus*, the group is very narrow indeed, has few bristles and has only two larger pairs (fig. 103a).

Key to the Larvae of the British Species of *Anopheles*

A. The six post-antennal hairs are prominent.

I. The six post-antennal hairs are pinnately-branched; fin of ninth segment present.

a. Outer anterior clypeal hair dendroid in shape; leaflets of float-hairs spring from an elongate capitulum which is sessile, or has a very wide stalk; the difference in size between the larger and smaller teeth of the comb considerable; smaller bristle of the outer pair at the apical end of the palp about three-quarters the length of the larger one . . . . . 1. *A. maculipennis*.

1. Palp of maxilla with a sub-apical branched hair.

α. 25–30 teeth in comb; three, four or even five secondary and tertiary teeth between each of the seven primary teeth; about 22 leaflets in each float-hair (figs. 80, 83) . . *A. maculipennis*, fourth larval instar.

β. About 16 teeth in comb; one or two secondary, and sometimes tertiary teeth between each of the seven primary teeth; about 14 leaflets in each float-hair (figs. 86, 89) . . *A. maculipennis*, third larval instar.

2. Palp of maxilla without a sub-apical hair; one or two secondary teeth between each of the seven primary teeth of the comb (figs. 92, 95) *A. maculipennis*, second larval instar.

b. Outer anterior clypeal hair simple, or once or twice split at the end; leaflets of float-hairs spring from a clavate capitulum which has a short narrow stalk; the difference in size between the larger and smaller teeth of the comb is but slight; smaller bristle of the outer pair at the apical end of the palp about half the length of the larger one . . . . . 2. *A. bifurcatus*.

1. Palp of maxilla with a sub-apical branched hair.

α. About 25 teeth in comb; one or two secondary teeth between each of the ten primary teeth; about 16 leaflets in each float-hair (figs. 81, 84) . . *A. bifurcatus*, fourth larval instar.

β. About 18 teeth in comb; one or two secondary teeth between each of the eight primary teeth; about 10 leaflets in each float-hair (figs. 87, 90) *A. bifurcatus*, third larval instar.

2. Palp of maxilla without a sub-apical hair; about 14 teeth in the comb, alternately larger and smaller (figs. 93, 96) . . . . *A. bifurcatus*, second larval instar.

II. The six post-antennal hairs simple, or, at most, forked ; a bunch of appressed bristles occupies the place of the fin of the ninth segment ; a secondary comb present.
  a. About 6 teeth in primary comb ; appressed bristles form a narrower group, and there are about three pairs of larger bristles (figs. 98, 100, 102) *A. maculipennis*, first larval instar.
  b. About 8 teeth in primary comb ; appressed bristles form a broader group, and there are about five pairs of larger bristles (figs. 99, 101, 103) . *A. bifurcatus*, first larval instar.

B. The six post-antennal hairs are very small . . . . 3. *A. plumbeus.*

I. Ninth abdominal segment with a fin.
  a. Maxillary palp with a sub-apical hair.
    1. All four anterior clypeal hairs simple or merely split once or twice ; sub-apical hair of palp freely branched ; about 16 teeth in the comb (figs. 82, 85) . *A. plumbeus*, fourth larval instar.
    2. All four anterior clypeal hairs freely split, especially the inner pair ; sub-apical hair of palp simple or merely split at the end ; about 12 teeth in the comb (figs. 88, 91) . . . . *A. plumbeus*, third larval instar.
  b. Maxillary palp without a sub-apical hair ; outer pair of anterior clypeal hairs twice forked, inner pair pinnately branched ; about 10 teeth in comb (figs. 94, 97) *A. plumbeus*, second larval instar.
II. A bunch of appressed bristles occupies the place of the fin of the ninth segment ; a secondary comb present (figs. 99a, 101a, 103a) . . . . . *A. plumbeus*, first larval instar.

b. Ochlerotatus.

It is unfortunate that the Museum Collection contains no larvae of *Aëdes cinereus*, except in the fourth instar. The younger stages of this species, therefore, have yet to be described. The next genus is *Ochlerotatus*, with its eight British species ; and the differences between the species, and, where known, between the different larval instar, will now be considered. The first instar of all the species (as far as it is known, see figs. 108, 116) can be distinguished from the succeeding instar by the following characters. There is no fin on the ninth segment ; only the distal part of the siphon is heavily chitinised ; the pecten has but six teeth, most of which are very wide, and with the main denticle not very much larger than the rest ; the tufted hair of the later instar is represented by a simple hair ; the scales of the comb form a single row ; there is an egg-breaking tooth on the upper

surface of the head ; all the post-antennal hairs lie approximately in a slightly-curved line, and the pre-antennal hairs are apparently absent. In the second to fourth instar there is a fin on the ninth segment ; the whole, or the greater part, of the siphon is heavily chitinised ; the pecten has more than sixth teeth, of which the main denticle is so much larger than the rest that it forms the greater part of the tooth ; the tufted-hair of the siphon has from two to six or more branches ; the scales of the comb form more than one row, or are irregularly arranged ; there is no egg-breaking tooth on the upper surface of the head ; the mid post-antennal hair has shifted forward and inward, and so comes to lie directly in front of the inner post-antennal hair ; and the pre-antennal hair is present and often highly-branched, but minute.

It is thus more easy to distinguish the first instar from the succeeding instar than to distinguish one species from another. Therefore, it is convenient to consider first the differences between the species in their second, third, and fourth larval instar, and then again in their first instar. With regard, then, to the second, third, and fourth larval instar, *O. rusticus* (fig. 112) and *O. vexans* (fig. 109) can be separated from the remaining five species with no difficulty, by their having the last one or two teeth of the pecten widely separated from the rest of the pecten and from each other. (The last tooth is *slightly* separated from the rest of the pecten as an occasional variation in other species of *Ochlerotatus*, especially *O. caspius*.) *O. rusticus* (fig. 112) has, moreover, three or four pairs of long simple hairs on the dorsal surface of the siphon, a second tufted-hair dorsal to, and about mid-way down the pecten, and the main tufted-hair lies decidedly ventrally with regard to the pecten. The second and third instar of *O. rusticus* and *O. vexans* have not been observed—moreover, the larval characters of *O. vexans* have been taken from the figure in Dyar, Howard and Knab (1912, The Mosquitoes of North and Central America, vol. ii., pl. lxvi.) of *O. sylvestris*, which is now considered to be the same species as the European *O. vexans*.

The larvae of the six remaining species are much more difficult to distinguish. *O. detritus* is perhaps the most easily separated owing to the anal gills which are very short and nearly globular, and the blunt comb-scales which are merely fringed and have not a la[illegible]

terminal spine (figs. 121, 122). It requires, however, a high magnifying power to see this clearly. The conspicuously paler bases of the antennae in the fourth instar and the pecten-teeth with their comparatively small, evenly graded denticles (figs. 121, 122) are also

FIG. 104.—Antenna of *Finlaya geniculata*.

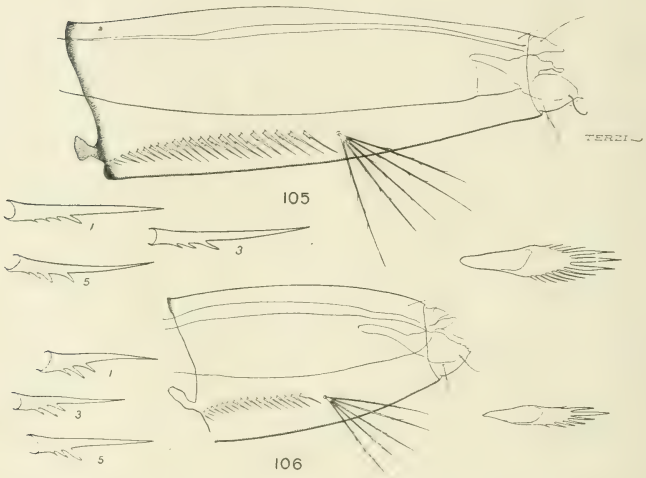


FIG. 105.—Siphon, pecten-teeth, and comb-scale of *O. caspius*, fourth larval instar.

FIG. 106.—Siphon, pecten-teeth, and comb-scale of *O. caspius*, third larval instar.

characteristic. The differences between the second, third, and fourth instar of *O. detritus* (and this is applicable to other species as well) are seen in the numbers of the pecten-teeth and comb-scales, and in the greater complexity of the post-antennal hairs and tufted-hair of the

siphon. But since these numbers and this complexity have a considerable range of individual variation, the characters given are not strictly diagnostic, but should be applied with the reservation

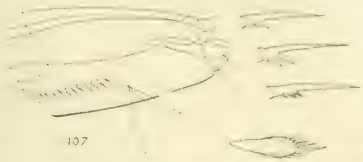


FIG. 107.—Siphon, pecten-teeth, and comb-scale of *O. caspius*, second larval instar.

FIG. 108.—Siphon, pecten-teeth, and comb-scale of *O. caspius*, first larval instar.

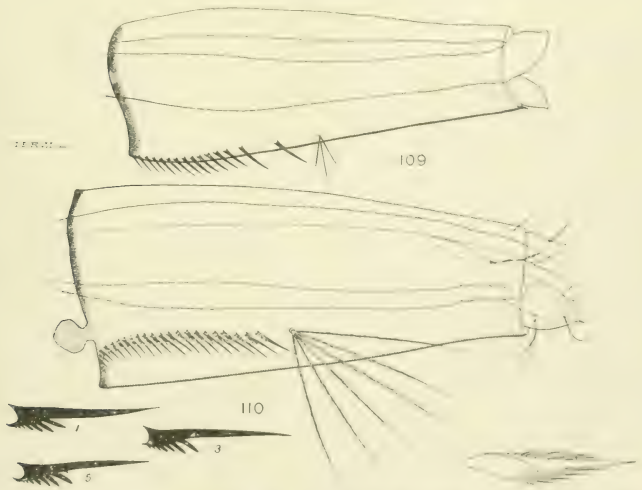


FIG. 109.—Siphon of *O. vexans*, fourth larval instar (after Dyar, Howard and Knab, as *Aëdes sylvestris*).

FIG. 110.—Siphon, pecten-teeth, and comb-scale of *O. [illegible]*, fourth larval instar.

that in any one specimen any character may vary beyond the prescribed limits. With this caution, it may be said that the third instar of *O. detritus* has ten to fourteen pecten-teeth, two or three

branches in the tufted hair, three or four branches in the outer post-antennal hair, and the other post-antennal hairs simple; while the fourth instar has eighteen to thirty pecten-teeth, four to nine branches in the tufted hair, more than four branches in the outer post-antennal hair, and the inner with two branches.

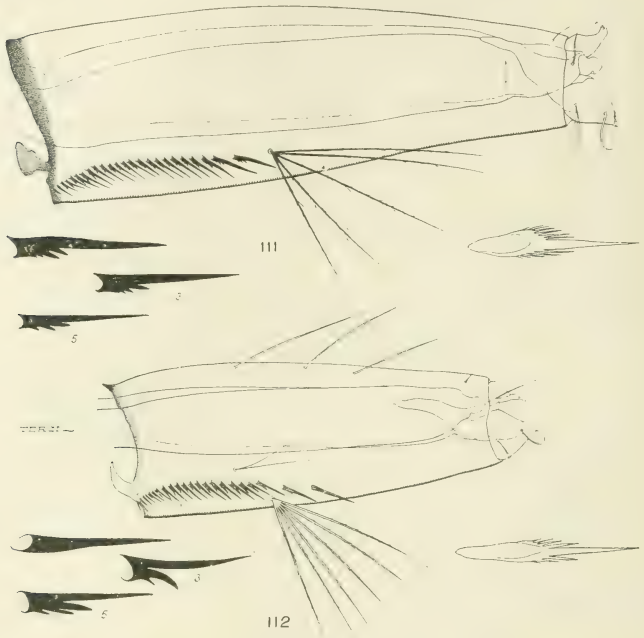


FIG. 111.—Siphon, pecten-teeth, and comb-scale of *O. annulipes*, fourth larval instar.

FIG. 112.—Siphon, pecten-teeth, and comb-scale of *O. rusticus*, fourth larval instar.

No satisfactory difference has yet been found between the larvae of *O. caspius* and *O. curriei*. The shape of the comb-scales and pecten-teeth shown in figs. 105–107, 113–115, 110–111, are the best means of distinguishing *O. caspius*, *O. nemorosus*, *O. waterhousei*, and *O. annulipes*. In *O. nemorosus* the terminal spine of the comb-scales

is very large indeed, and the lateral spines form merely fringing bristles (figs. 113–115); in the other three species the terminal spine (or, in *O. caspius* two or three spines) is the largest, but not so much larger than the lateral spines. There are comparatively few denticles in the pecten-teeth of *O. caspius* (figs. 105–107), and *O. annulipes* (figs. 110–111), while there are many in those of *O. waterhousei*.[1]

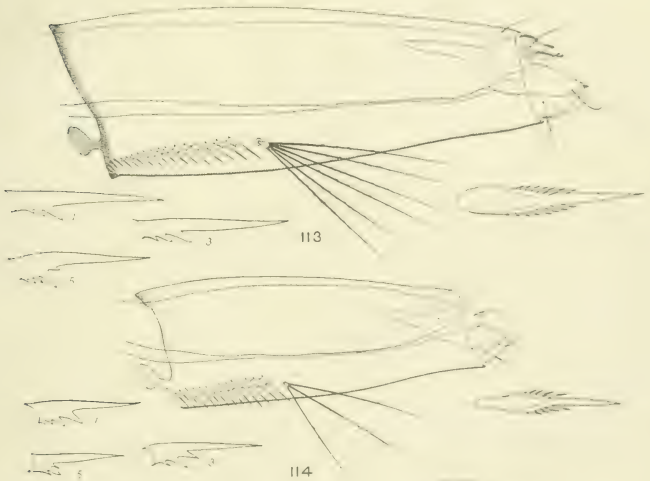


FIG. 113.—Siphon, pecten-teeth, and comb-scale of *O. nemorosus*, fourth larval instar.

FIG. 114.—Siphon, pecten-teeth, and comb-scale of *O. waterhousei*, fourth larval instar.

The antennae are conspicuously paler at the base in the fourth instar of *O. caspius*, less so in *O. waterhousei* and *O. annulipes*, and uniformly pigmented in *O. nemorosus*. Generally, in *O. caspius* the tufted hair lies decidedly beyond the middle of the pecten. In *O. nemorosus* the anal gills are large and generally longer than the last segment.

[1] The examination of more material has shown that these differences are not constant, and a satisfactory distinguishing character for larvae of *O. waterhousei* and *O. annulipes* has yet to be found.

The second and third instar of *O. waterhousei* and *O. annulipes* have not been examined, but the earlier stages of *O. caspius* and *O. nemorosus* are known (figs. 106–107, 114–115). The pecten-teeth number nine to thirteen, fourteen to seventeen, and nineteen to twenty-six in the second, third, and fourth instar of *O. caspius*, and twelve to fourteen, twelve to sixteen, and eighteen to twenty-six in *O. nemorosus*; the tufted hair has three to four, four to five, and five to six branches in *O. caspius*, and two to three, three to five, and four to six in *O. nemorosus*; the outer post-antennal hair has two, five, and eight branches in *O. caspius*, and two, three, and five to eight in *O. nemorosus*; the mid-hair is simple in all instar of both species, except the fourth, of *O. nemorosus*, when it generally has two branches; the inner hair has

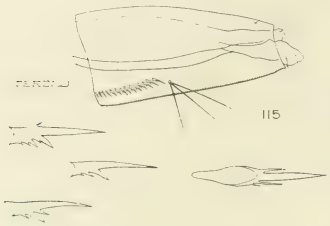


FIG. 115.—Siphon, pecten-teeth, and comb-scale of *O. nemorosus*, second larval instar.

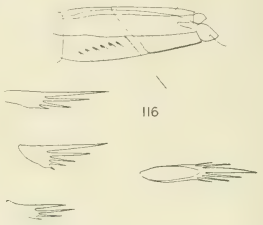


FIG. 116.—Siphon, pecten-teeth, and comb-scale of *O. nemorosus*, first larval instar.

generally two branches in *O. caspius*, except in the fourth instar, when it is simple, and in *O. nemorosus* it is simple in the second instar, sometimes forked in the third, and generally forked in the fourth larval instar.

The first larval instar has been observed in *O. caspius* and *O. nemorosus* only, and the shape of the comb-scales affords the best character for separating them. Generally speaking, the same differences separate the comb-scales of the first instar as those of the succeeding instar. Thus, in *O. nemorosus* the terminal spine is considerably bigger than the lateral bristles; and in *O. caspius* the terminal spine, though larger than most of the lateral spines, is hardly larger than its neighbours (figs. 108, 116).

These differences are expressed in a tabular form in the following keys:

KEY TO THE LARVAE OF BRITISH SPECIES OF *Ochlerotatus*, FOURTH INSTAR ONLY.

A. The last one or two teeth separated by wide gaps from each other and from the rest of the pecten.

I. Tufted hair lies more or less in a line with the pecten; no small second tufted hair dorsal to the pecten; nor any simple hairs on the dorsal surface of the siphon (fig. 109) 3. *O.* [illegible]

II. Large tufted hair lies ventral to the pecten; a small tufted hair lies dorsal to and about half-way along the pecten; three or four pairs of long, simple hairs on the dorsal surface of the siphon (fig. 112) . . . . . 8. *O. rusticus*.

B. Pecten-teeth evenly spaced (except that sometimes the last tooth is a little further removed from the penultimate tooth than the penultimate from the anti-penultimate).

I. Antennae paler at the base; anal gills shorter than the last segment.

a. Comb-scales blunt, ending in several sub-equal bristles; pecten not half as long as the siphon (fig. 121) . . . 6. *O. detritus*.

b. Comb-scales sharp, ending in one or two teeth somewhat larger than the rest (or sometimes in one decidedly larger than the rest); pecten generally half as long as the siphon (fig. 105) . . . . . 1. *O. caspius*, and 2. [illegible]

c. Comb-scales sharp, ending in one spine conspicuously larger than the rest; pecten not half as long as the siphon.

1. Pecten-teeth stouter with more denticles (fig. 110)[1] 4. *O. waterhou*[illegible]

2. Pecten-teeth more slender with fewer denticles (fig. 111) 5. *O. annulip*[illegible]

II. Antennae uniformly pigmented; anal gills very large and tapering, usually longer than the last segment; comb-scales ending in a terminal spine so large that the others appear as mere hairs or bristles fringing the base of the terminal spine (fig. 113) . . . . . 7. [illegible]

KEY TO THE LARVAE OF BRITISH SPECIES OF *Ochlerotatus*, IN EITHER ALL THE INSTAR HITHERTO OBSERVED.

A. Fin of the ninth abdominal segment present; more than six teeth in pecten; main denticle of pecten-tooth so much larger than the rest that it forms the main part of the tooth; tufted hair with from two to six branches; no egg-breaking tooth on the dorsal surface of the head; mid pair of post-antennal hairs lying nearly directly anterior to the inner pair.

Second, third, and fourth instar of all British species.

I. No small second tufted hair on siphon dorsal to pecten, nor pairs of simple hairs on the dorsal surface of the siphon.

[1] See footnote on p. 63.

a. The last one or two pecten-teeth separated by wide gaps from each other and from the rest of the pecten (fig. 109) . . . 3. *O. rerani*.

b. Pecten-teeth evenly spaced (except that sometimes the last tooth is a little further removed from the penultimate than the penultimate from the ante-penultimate).

1. Scales of comb blunt, ending in several sub-equal bristles . . . . . 6. *O. detritus*.

a. Pecten-teeth 18–30; four to nine branches in tufted hair; outer post-antennal hair with more than four branches; inner with two branches; antennae conspicuously paler at the base (fig. 121) *O. detritus*, fourth larval instar.

b. Pecten-teeth 10–14; two to three branches in tufted hair; outer post-antennal hair with three to four branches; other antennal hairs single; antennae uniformly pigmented (fig. 122) . . *O. detritus*, third larval instar.

2. Scales of comb pointed, ending in one or two spines slightly larger, or one spine conspicuously larger than the other spines or bristles.

a. Terminal spine or spines of comb-scales, though slightly or conspicuously larger than the fringing spines, not so much larger that these appear as mere bristles, but rather as smaller spines of similar nature.

i. Tufted hair generally decidedly beyond the middle of pecten. Comparatively few denticles on pecten-teeth . . . . . 1. *O. caspius* and 2. *O. curtici*.

a. Pecten-teeth 19–26; five to six branches in tufted hair; outer post-antennal hair with about eight branches, the others generally simple; antennae conspicuously paler at the base (fig. 105) *O. caspius*, fourth larval instar.

b. Pecten-teeth 14–17; four to five branches in tufted hair; outer post-antennal hair with about five branches, the mid generally simple and the inner generally with two branches; antennae hardly paler at the base (fig. 106) . . *O. caspius*, third larval instar.

c. Pecten-teeth 9–13; three to four branches in tufted hair; outer post-antennal hair with two branches, the mid-hair simple and the inner generally with two branches; antennae uniformly pigmented (fig. 107) . *O. caspius*, second larval instar.

ii. Tufted hair at about the middle of the pecten; antennae hardly paler at the base.

a. Pecten-teeth stouter and more numerous, with some minute denticles at the base, and others often between the larger denticles (fig. 110)[1] 4. *O. waterhousei*.

b. Pecten-teeth more slender and fewer, without minute denticles occurring between the larger denticles (fig. 111) . . . . . 5. *O. annulipes*.

[1] See footnote on p. 63.

g. Terminal spine of comb-scales so much larger than the others that these appear as mere hairs or bristles fringing the base of the terminal spine; antennae uniformly pigmented; anal gills longer than the last segment; teeth of pecten with the last denticle conspicuously the largest . . . . . *O.*

i. Pecten-teeth 18–26; four to six branches in tufted hair; outer post-antennal hair with five to eight branches, the others generally bifid; comb-scales generally arranged in about four irregular rows of seven or eight (fig. 113) . *O. nemorosus*, fourth larval instar

ii. Pecten-teeth 12–16; three to five branches in tufted hair; outer post-antennal hair with five branches, the others simple or sometimes the inner hair is bifid; comb-scales generally arranged in three irregular rows of about eight each (fig. 114 *O. nemorosus*, third larval instar

iii. Pecten-teeth 12–14; two to three branches in tufted hair; outer post-antennal hair with two branches, the others simple; comb-scales generally arranged in two irregular rows of seven each (fig. 115 . . . *O. nemorosus*, second larval instar

H. A second small tufted hair lying dorsal to and about half-way along the pecten; three or four pairs of long simple hairs on the dorsal surface of the siphon; the main tufted hair lies ventral to the pecten; the last one or two teeth of the pecten are widely separated from each other and from the rest of the pecten (fig. 112) . . . . . *O.*

B. Fin of ninth abdominal segment absent; six teeth in pecten; main denticle of pecten-teeth not so conspicuously larger than the rest that it forms the main part of the tooth; tufted hair of third and fourth instar, simple in first instar; an egg-breaking tooth on the dorsal surface of the head; all post-antennal hairs approximately in a curved line. *First larval instar of O. cantans*, *O. nemorosus*, and probably the other British species

I. Scales of comb with terminal spine hardly larger than its neighbours (fig. 108) . . . . . *O. caspius*, first larval instar

II. Scales of comb with terminal spine considerably larger than the fringing spines (fig. 116). . . . *O. nemorosus*, first larval instar

c. Finlaya.

The larva of *Finlaya geniculata* is known from those of the different species of *Ochlerotatus* by the antennae which are smooth and have not the scattered appressed spines usual in gnat-larvae (fig. 104); and in all the instar but the first by having the comb-scales arranged in a single line. The very large anal gills, too, are sausage-shaped instead of tapering as in *Ochlerotatus*. The larva of

Finlaya geniculata shares with exotic species of this genus the habit of living in tree-holes like *Anopheles plumbeus* and *Orthopodomyia.*

With the reservations already made with regard to the larvae of *Ochlerotatus* in their different instar, it may be said of *F. geniculata* that the pecten-teeth in the second, third and fourth larval instar

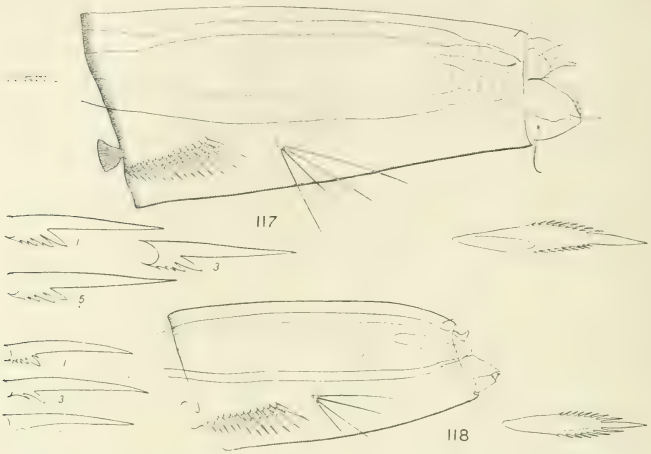


FIG. 117.—Siphon, pecten-teeth, and comb-scale of *F. geniculata*, fourth larval instar.

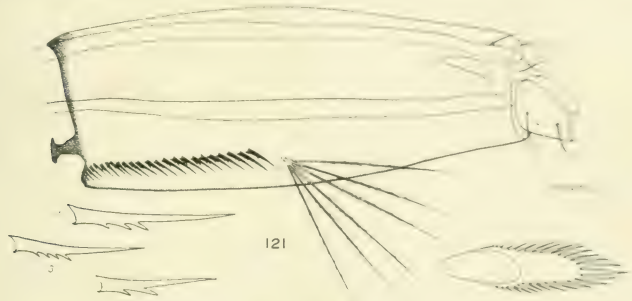
FIG. 118.—Siphon, pecten-teeth, and comb-scale of *F. geniculata*, third larval instar.

FIG. 119.—Siphon, pecten-teeth, and comb-scale of *F. geniculata*, second larval instar.

FIG. 120.—Siphon, pecten-tooth, and comb-scale of *F. geniculata*, first larval instar.

have, respectively, eight, twelve and fourteen to eighteen teeth ; the comb seven, twelve and fourteen scales ; the tufted hair, two, four and four or five branches (see figs. 117–119) ; the outer post-antennal hair has two or three branches in the third, and three or four branches in the fourth instar ; and the mid and inner post-antennal hairs are simple, though in the fourth instar the inner pair sometimes has two branches.

The first instar may be known by possessing no fin on the last segment; about six pecten-teeth; a simple hair on the siphon and egg-breaking tooth on dorsal surface of head; and all the post-antennal hairs forming a single row (fig. 120).



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122

FIG. 121.—Siphon, pecten-teeth, and comb-scale of *O. detritus*, fourth larval instar.

FIG. 122.—Siphon, pecten-teeth, and comb-scale of *O. detritus*, third larval instar.

KEY TO LARVAL INSTAR OF *Finlaya geniculata*.

A. Fin of ninth abdominal segment present; more than six teeth in pecten; tufted hair with two to six branches; no egg-breaking tooth on dorsal surface of head; mid pair of post-antennal hairs lying directly anterior to the inner pair. Second, third and fourth larval instar.

I. Pecten-teeth 14–18; four to five branches in tufted hair; outer post-antennal hair with from two to four branches; middle and inner simple or with two branches; about fourteen scales in comb (fig. 117) . . *F. geniculata*, fourth larval instar

II. Pecten-teeth about 12; four branches in tufted hair; outer post-antennal hair with two or three branches; middle and inner simple; about twelve scales in comb (fig. 118) . . . . . *F. geniculata*, third larval instar

III. Pecten-teeth about 8; two branches in tufted hair; about seven scales in comb (fig. 119) . *F. geniculata*, second larval instar

B. Fin of ninth abdominal segment absent ; about six teeth in pecten ; hair on siphon simple ; an egg-breaking tooth on dorsal surface of head ; all post-antennal hairs simple and lying in a single row (fig. 120) . . . . . *F. geniculata*, first larval instar.

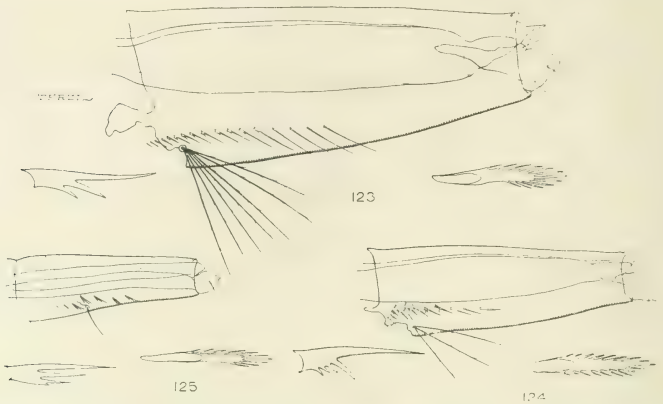

FIG. 123.—Siphon, pecten-tooth, and comb-scale of *Theobaldia annulata*, third larval instar.

FIG. 124.—Siphon, pecten-tooth, and comb-scale of *Theobaldia annulata*, second larval instar.

FIG. 125.—Siphon, pecten-tooth, and comb-scale of *Theobaldia annulata*, first larval instar.

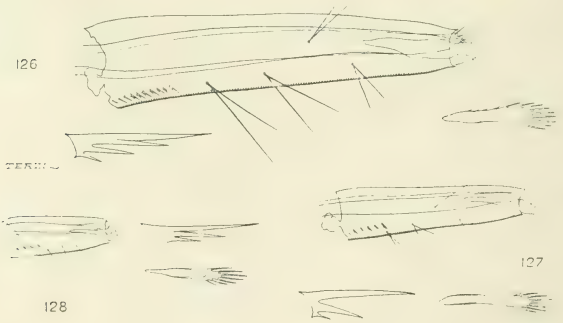

FIG. 126.—Siphon, pecten-tooth, and comb-scale of *Culex pipiens*, third larval instar.

FIG. 127.—Siphon, pecten-tooth, and comb-scale of *Culex pipiens*, second larval instar.

FIG. 128.—Siphon, pecten-tooth, and comb-scale of *Culex pipiens*, first larval instar.

d. Theobaldia.

The four larval instar of *Theobaldia annulata* differ in much the same manner as the instar of the different species of *Culex*, namely, in the number of pecten-teeth and comb-scales, and in the complexity of their post-antennal hairs and tufted hair. The differences are best tabulated as follows :—

A. At least inner and outer post-antennal hair compound ; tufted hair with from three to eight branches, and situated near the proximal end of the pecten ; comb-scales in more than one row, or irregularly arranged ; pecten-teeth more than seven in number ; no egg-breaking tooth on upper surface of head ; a fin present on ninth abdominal segment.

Second, third, and fourth larval instar.

I. Outer post-antennal hair with about twelve branches, mid with from one to four branches, and inner with about six branches ; tufted hair with about eight branches ; comb-scales, about sixty in number, in several irregular rows ; pecten-teeth about thirty in number, of which about the last six are widely-spaced and many are hair-like (fig. 76).

Theobaldia annulata, fourth larval instar.

II. Outer post-antennal hair with about five branches, mid post-antennal hair simple, inner with three branches : tufted hair with seven branches ; comb-scales, about fifty in number, arranged in several irregular rows ; pecten-teeth about seventeen, of which about the last six are widely-spaced and hair-like (fig. 123).

Theobaldia annulata, third larval instar.

III. Outer post-antennal hair with about three branches, mid post-antennal hair simple, inner with two branches ; tufted hair with about three or four branches ; comb-scales, about twenty in number, in two irregular rows ; pecten-teeth about fourteen in number, of which about the last three are widely-spaced and hair-like (fig. 124).

Theobaldia annulata, second larval instar.

B. All the post-antennal hairs simple ; tufted hair of second to fourth instar is a simple hair in first instar, and situated ventrally to and about half-way down the pecten ; comb-scales about ten to twelve in a single row ; pecten-teeth six to seven in number, and not hair-like ; an egg-breaking tooth on the upper surface of the head ; no fin on the ninth abdominal segment (fig. 125). *Theobaldia annulata*, first larval instar.

e. Culicella.

The two species of *Culicella* can be more readily determined by their larval than by their adult characters. In *C. morsitans* (fig. 77) the axis of the pecten is more or less parallel with that of the siphon ;

and the siphon has no scattered single spines on its surface. In *C. fumipennis* (fig. 78), the axis of the pecten lies obliquely with regard to that of the siphon, and there are scattered single spines on the rest of the siphon.

The earlier larval instar have not been observed.

f. Culex.

The larva of *Culex apicalis* has a more slender siphon (fig. 129) than *C. pipiens*. The species ranks as British only on the strength of an isolated capture. In *Culex pipiens* (figs. 79, 126–8) there are on the siphon four pairs of tufted hairs (three only in first instar), called so because in the second to fourth instar in other British Culicines they have at least two branches. They are often simple in the earlier instar of *Culex pipiens*, generally double, and in the last two instar may have three or even four branches. They lie more or less in a line with the

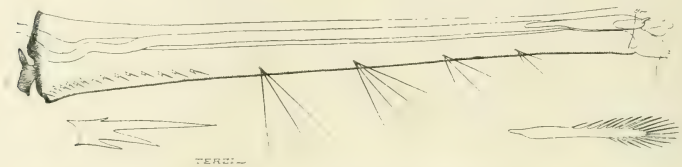

FIG. 129. Siphon pecten tooth, and comb-scale of *Culex apicalis*, fourth larval instar.

pecten, but the first pair (tufted hair 1), lying near the distal end of the pecten, is generally more or less ventral to the pecten; and the third pair (tufted hair 3) generally lies dorsal to the line of the rest. The following key gives in tabular form the differences between the instar, but it must be borne in mind that the numbers of the pecten-teeth, comb-scales and branches in the hair have a considerable margin of variation, and so those given in the key are only approximate.

A. No fin on ninth segment; three pairs of simple (not tufted hairs on siphon; about four teeth in pecten; comb-scales in a single row of about eight to ten; all post-antennal hairs simple; an egg-breaking tooth on dorsal surface of head (fig. 128) . . . . . *Culex pipiens*, first larval instar.

B. A fin on ninth segment; four pairs of hairs (simple or tufted) on siphon; more than four teeth in pecten; comb-scales in at least two rows or irregularly arranged; post-antennal hairs at least double; no egg-breaking tooth on dorsal surface of head.

I. Comb-scales in two irregular rows of about ten scales in each row; five to seven teeth in pecten; all four pairs of tufted hairs on siphon may have two branches, but numbers three and four may be simple; outer post-antennal hair with two or three branches, mid and inner with two branches (fig. 127) . . . *Culex pipiens*, second larval instar.

II. Comb-scales in at least three irregular rows, tending to form a triangular patch containing thirty to fifty teeth.

a. Ten teeth in pecten; tufted hairs 1 and 2 generally double, 3 and 4 often double but may be simple; outer post-antennal hair with from three to six branches, mid with two or three branches, and inner with three branches (fig. 126) . . . . . *Culex pipiens*, third larval instar.

b. Twelve to fifteen teeth in pecten; tufted hair 1 generally with three branches, 2 with three or even four branches, 3 generally with two branches, and 4 generally with three branches; outer post-antennal hair with from seven to nine branches, mid with three or four branches, and inner with four or five branches (fig. 79).

Culex pipiens, fourth larval instar.

III.—SYSTEMATIC ACCOUNT.

1.—ANOPHELES, Meigen.[1]

Anopheles; J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 10.

Genosyntypes, *Culex bifurcatus* Linnaeus and *Anopheles maculipennis* Meigen.

Genolectotype, *Culex bifurcatus* Linnaeus. See D. W. Coquillett, 1910, Proc. United States National Museum, vol. xxxvii, p. 507.

1. *Anopheles maculipennis* Meigen.[2]

Plate I., and figs. 7, 10, 12, 15, 18, 27, 40, 44, 80, 83, 86, 88, 92, 95, 98, 100, 102.

Anopheles maculipennis, Hoffmgg.; Meigen, 1818, *op. cit.*, p. 11. [Note: Meigen's ascription of the name *maculipennis* to Hoffmannsegg, probably refers to an MS. label.]

[1] For an account of the distribution of *Anopheles* in Britain, see G. H. F. Nuttall, L. Cobbett and T. Strangeways-Pigg, 1901, Journal of Hygiene, vol. i, pp. 4-44; and W. D. Lang, 1918, A Map showing the known distribution in England and Wales of the Anopheline Mosquitoes, British Museum (Natural History); and Florence E. Jarvis, 1919, Annals of Applied Biology, vol. vi, pp. 40–7.

[2] For a full account of the anatomy and life-history of this species, see G. H. F. Nuttall and A. E. Shipley, 1901-1913, Journal of Hygiene, vol. i, nos. 1 and 2, vol. ii, no. 1, and vol. iii, no. 2.

The spotted wings are generally enough to distinguish *A. maculipennis*, not only from the other British species of *Anopheles*, but from all other British gnats, except *Theobaldia annulata*; and even if only the rubbed wing is available, the relative positions of the cross-veins, as described above, will distinguish these two forms (fig. 33). If the wings are rubbed, or if for any other reason there is doubt, the best characters for distinguishing *A. maculipennis* from *A. bifurcatus* and *A. plumbeus* are those of the thoracic scale-tuft (see above, p. 33, figs. 40–41). The difference between the scutella of *A. maculipennis* and *A. bifurcatus* is too slight to be of much value; and to compare the breadth of the wing-scales, it is necessary to have already the wings of the two species as standards. In the case of a male, the characters of the genitalia (fig. 44) are absolutely diagnostic.

The larvae of *A. maculipennis* are most easily recognised, especially when alive, by the dendroid outer anterior clypeal hair (figs. 10, 80, 86, 92). This lies over the brush, and, in the living larva, is seen at once with a hand-lens when the larva even momentarily retracts its brushes.

A. maculipennis appears to be common all over England and Wales wherever breeding conditions are suitable. Its abundance in any district depends, apparently, partly upon the locality itself, but also varies from year to year. Its distribution in Scotland and Ireland has not been worked out at all fully; but since the species has been found in both countries, it is probably widely distributed where there are the requisite breeding conditions. The favourite breeding-places seem to be the shallow margins of weedy, but not foul, calm, open[1] water; and there is also required a certain degree of warmth. That *A. maculipennis* does not avoid brackish water is shown by its abundance, observed by Dr. Davidson, in the brackish-water dykes in the neighbourhood of Sandwich, Kent.

The eggs are first produced when the flies emerge from hibernation, in March, in mild seasons, but generally in April. They are laid, probably during the night or early morning, and singly, not, as in

[1] Mr. F. W. Edwards has observed that, even when found in the same water, *A. maculipennis* prefers an *open* station, while *A. bifurcatus* prefers a *shaded* station. His attention was also drawn to the fact by Dr. Penrose of Bournemouth. See also J. Feytaud and E. Gendre, 1919, Bull. Soc. Path. Exot. Paris, vol. xii, pp. 178–182.

Culex, in rafts formed of numbers glued together; though they often take up definite positions of equilibrium with regard to one another and often form regular patterns. Within a few days the larvae are hatched, and within a few weeks emerge as flies, having passed through their four larval instar as well as the pupal instar. The advent of the newly-emerged flies in a district is announced by the presence of males as well as females; for the hibernating flies are females only. During the day-time and in inclement weather the flies of both sexes prefer to shelter in buildings and similar situations; but especially in the evenings in calm weather the females fly forth and bite, and the males gather in swarming companies. Fresh broods of eggs continue to be laid throughout the summer, until about the end of September. By the middle of October no more larvae or pupae are found in fresh waters nor male flies in the land. The female flies shelter in buildings, and are especially fond of occupied cowsheds, pigstyes and stables, where they keep comparatively warm, and in the milder spells of winter always have a meal handy. In these situations they may be found in immense numbers, and are particularly fond of settling upon cobwebs. A wholesale destruction of these hibernating females promises to be an effective means of reducing the numbers of *A. maculipennis* in a district in the following season.

Towards the end of summer the flies are often found with larval water-mites attached to the bodies, wings or legs.[1] These mites have been observed to suck and weaken the flies. They are comparatively rarely found on the larvae; and how they obtain a hold on the fly is not known. Nor is it easy to understand how they return to the water. There is no reason why a male fly should approach water; and a female weakened and finally dying under the attack of a mite would in the majority of cases collapse far (from the mite's point of view) from any water. A mite on *A. maculipennis* captured by Mr. D. J. Scourfield during August was submitted to Mr C. Soar, who kindly determined it for me and pronounced it to be the larva of a species of *Arrhenurus*. Larval *Trombidium* (possibly the same mite under another name) have also been recorded from the flies of *Anopheles maculipennis* and *A. bifurcatus*. Again, J. Curtis (1834, British Entomology, explanation of pl. 210) quotes Haliday as saying

[1] See C. Wesenberg-Lund, 1918, Vandensl. Meddel. fra Dansk naturh. [illegible]

that *A. maculipennis* "are very much infested by a small reddish parasite (*Ocypete rubra* ?) ; I have found ten of these attached to the abdomen of a male."

A larva collected by Major A. Macdonald in Kew Gardens was found to be full of the diatom *Fragilaria* sp., probably *F. virescens* (kindly determined for me by Mr. F. B. Taylor, of Bournemouth). Occasional diatoms occur in larval mosquitoes, but it is not usual to find them in large numbers ; and, since diatoms must often abound where the larvae of *A. maculipennis* are feeding, it appears probable that the diatoms in the case described were eaten deliberately.

2. *Anopheles bifurcatus* (Linnaeus).

Plate II., and figs. 41, 42, 45, 81, 84, 87, 90, 93, 96, 99, 101, 103.

Culex bifurcatus ; Linnaeus, 1758, Systema Naturae, Regnum Animale, editio decima, p. 603.

As a general rule, the unspotted wings of *A. bifurcatus* readily distinguish it from *A. maculipennis* and the coloration of the thorax from *A. plumbeus*. But in doubtful cases the characters of the thoracic scale-tuft are the most useful criterion to distinguish *A. bifurcatus* from *A. maculipennis* (figs. 40–1) ; and the shape of the scutellum to distinguish *A. bifurcatus* from *A. plumbeus* (figs. 42–3). In the case of a male, the characters of the genitalia are absolutely diagnostic of the three species (figs. 44–46). These points of difference have been described in detail above, as also have the larval characters, the most useful of which are the simpler outer anterior clypeal hairs (seen best in the live larva above the brushes) to distinguish it from *A. maculipennis*, and the large, branched post-antennal hairs to distinguish it from *A. plumbeus* (figs. 81, 87, 93).

A. bifurcatus is as widely distributed as *A. maculipennis* in England and Wales, and is probably equally common. In a few localities it has been recorded as commoner. But the numbers of *A. maculipennis* vary considerably from year to year in a given district, while those of *A. bifurcatus* remain more constant. *A. maculipennis*, however, is the more noticeable species, owing to its fondness for entering houses and its habit of hibernating as a female fly.

A. bifurcatus hibernates as a larva (probably, as a rule, if not always, in the third instar), which, as soon as the spring-weather comes, completes its development and emerges as a fly. Consequently, male *A. bifurcatus* are found earlier in the season than male *A. maculipennis*, which have to undergo their whole life-history from the egg at the beginning of each season, while *A. bifurcatus* starts as a three-quarter grown larva. In 1918, *A. bifurcatus* appeared as early as February.

The habit of hibernating as a larva probably explains the more constant numbers of *A. bifurcatus* from year to year. For a few warm days in early spring, followed by cold weather, will tempt forth the hibernating females of *A. maculipennis* into the open, and they will stand the chance of being overtaken and destroyed by the suddenly returning cold. Whereas the larva in the water remains under for more uniform conditions, and can live in or under ice.

The general habits of the two species are similar. *A. bifurcatus*, however, prefers the shelter of foliage to buildings, and therefore is comparatively uncommon in houses and more common in wooded country ; and it will bite more readily by day than *A. maculipennis*. Adult *A. bifurcatus*, however, have been observed by Mr. F. W. Edwards resting under the raised floor of a bungalow at Wood Walton Fen, Hunts, preferring cobwebs for their settling places. In one case only was a mosquito observed to have been caught by a spider and shrouded in silk. In the Sandwich district, where it was remarked that *A. maculipennis* flourished in brackish water, the evidence shows that *A. bifurcatus* prefers the fresh, if it does not actually avoid brackish water. In the same district *A. bifurcatus* has also been found in a wooden vessel in a farmyard —practically a "water-butt," which is a most unusual situation for an *Anopheles*, and unknown to harbour the genus in town areas. In Palestine during 1918, Major E. E. Austen, D.S.O., saw *A. bifurcatus* breeding in wells and underground cisterns, and mentions it especially as abundant in wells of the orange gardens near Jaffa.

Larval mites are found on *A. bifurcatus* towards the end of the summer, as they are on *A. maculipennis*. Remarks on these will be found in the description of the latter species.

3. *A. plumbeus* Stephens.

Plate III., and figs. 43, 46, 82, 85, 88, 91, 94, 97, 99a, 101a, 103a.

Anopheles plumbeus; J. F. Stephens, 1828, Zoological Journal, vol. iii, p. 503.

Anopheles nigripes, n. sp.; C. Staeger, 1839, Kroyer's Naturhistorisk Tidschrift, vol. ii, p. 552.

The small size and dark colouring of *A. plumbeus* with the ashy-grey longitudinal thoracic markings will generally distinguish it from *A. bifurcatus*. But, in a case of doubt, the shape of the scutellum (fig. 43) and, in the male, the genitalia (fig. 46) afford the best criteria. It is unlikely that *A. plumbeus* and *A. maculipennis* will be confused, but the differences described above (pp. 34–5) should obviate all difficulties. The larva of *A. plumbeus* has a more stumpy look than that of *A. maculipennis* and *A. bifurcatus*, and may be most easily distinguished from the larvae of both species by the post-antennal hairs, which are exceedingly small, difficult to see, and simple, instead of pinnately branched. The outer anterior clypeal hairs are simple, or nearly so (figs. 82, 88, 94).

A. plumbeus appears to be widely distributed in England and Wales, and is common in some localities. It also occurs in Scotland and Ireland. On several occasions it has been taken in houses, though essentially a sylvan species; and, as far as is known, confined during its larval and pupal life to water-filled holes in trees.[1] The larvae of *Finlaya geniculata* are often found sharing these holes with *A. plumbeus*.[2] *A. plumbeus* larvae have been found during the winter (1918) by F. W. Edwards, and I have kept in captivity from September, 1918, till April, 1919, larvae of *A. plumbeus* captured during August, 1918, by Angus Macdonald, jun., at Culross, Fifeshire. A curious point with regard to the breeding of *A. plumbeus* is the apparent scarcity of the larva compared with the frequency of the imago. In more than one district where the fly is common, a search in likely tree-holes has failed to reveal the larva, or no tree-holes have been discovered. Observers report that *A. plumbeus* bites more viciously

[1] Beech-trees as a rule, but it has been taken from Chestnut (24, iii, 1919; Botanical Gardens, Cambridge; F. W. Edwards), and probably occurs in any trees providing suitable holes. See also under *Ochlerotatus geniculatus*. Theobald records *A. plumbeus* from a peat-cutting.

[2] Both species have also been taken with *Orthopodomyia* and *Stegomyia*, see pp. 109–10.

than the other two British *Anopheles*, and by day as well as by night. It has quite lately been established that *A. plumbeus* can be infected with malaria; see B. Blacklock and H. F. Carter, 1919, Ann. Trop. Medicine and Parasitology, vol. xiii, p. 187.

II. AËDES, Meigen.

Aedes, Hoffmgg.; J. W. Meigen, 1818, Syst. Beschr. bekannt. Europ. zweifl. Insekten, vol. i, p. 13. Genotype, *Aedes cinereus*, Meigen. [Note: Meigen's ascription of the name to Hoffmannsegg, refers to an MS. label by that collector on the material Meigen was describing.

1. *Aëdes cinereus* Meigen.

Figs. 5, 11, 13, 14, 17, 20, 75.

? *Culex ciliaris*: Linnaeus, 1767, Systema Naturae, editio duodecima reformata, vol. i, part 2, p. 1002.

Aëdes cinereus, Hoffmgg.; J. W. Meigen, 1818, Syst. Beschr. bekannt. Europ. zweifl. Insekten, vol. i, p. 13. [Note: See above under the genus *Aedes*.

Aëdes rufus, mihi.: F. A. Gimmerthal, 1845, Bull. Soc. Imp. Nat. Moscow, vol. xviii, p. 295.

Culex nigritulus: J. W. Zetterstedt, 1850, Diptera Scandinaviae, vol. iii, p. 3459.

non Culex nigritulus, Zetterstedt: F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. ii, p. 140, which is *Culex pipiens*, Linnaeus, var. *dolierum*, F. W. Edwards, q.v.

Aëdes fuscus, n. sp.; C. R. Osten Sacken, 1877, Bull. United States Geol. and Geogr. Survey, vol. iii, p. 191.

Aëdes leucopygus, n. sp.; A. Eysell, 1903, Abhandlungen und Bericht des Vereins für Naturkunde zu Kassel, vol. xlviii, p. 285.

The male of *Aëdes cinereus* may at once be known by its very short palpi. The female at first sight looks like an obscure *Ochlerotatus*, since it has the pointed abdomen of that genus. The marked contrast, however, in the female, between the reddish ground-colour of the thorax and the almost black head and abdomen, sufficiently distinguish it at a glance from the various species of *Ochlerotatus*, and an examination under a high-power lens or microscope shows the wide scales on the crown of the head in both sexes. In the male the thorax is black. The larva generally resembles those of the various species of *Ochlerotatus*, but is distinguished from these by the comparative slenderness of the siphon and by the position of the hair-tuft decidedly beyond the middle of the siphon (fig. 75).

F. W. Edwards considers the North American *Aëdes fuscus* to be identical with the European *A. cinereus*. In America *A. fuscus* is believed to pass the winter in the egg. We have no records of *Aëdes cinereus* during the winter, and it may be that it winters as an egg in Britain as it is supposed to do in America.

A. cinereus in Europe has been recorded from Norway, Sweden, Austria, Hungary and Italy (see F. V. Theobald, 1901, Monograph of the Culicidae or Mosquitoes, vol. ii, p. 234, and 1907, vol. iv, p. 539); from Germany (Habichts-Wald, W. of Cassel, Hessen, see A. Eysell, 1903, Abh. Ber. Ver. Naturk Kassel, vol. xlviii, p. 285); from Holland (see J. C. H. de Meijere, 1911, Tidschr. o. Entomologie, vol. liv, p. 148); Denmark; and from Russia (see under *Aëdes rufus*).

Though widely distributed, *Aëdes cinereus* does not appear to be very common in Britain; or, at least, not often observed. The general situations indicated in the British records suggest that it is mainly a river-haunting species. I have gathered the following records:—

Cambs.—Baitsbite, N.E. of Cambridge, Chippenham, N. of Newmarket, and Wicken, S. of Ely. *See F. W. Edwards*, 1912, *The Entomologist, vol. xlv, p.* 260.

Dorset.—Studland. *See F. W. Edwards, under Cambridgeshire records.*

Hants.—Bournemouth; flies and larvae; 10 and 11, vi, 1908; colld. H. J. Waddington. *British Museum Collection.*

Brockenhurst; flies and larvae; 11 and 26, vi, 1906; colld. C. O. Waterhouse. *British Museum Collection.*

Herts.—Radwell, near Letchworth. *F. W. Edwards colld.*

Hunts.—Wood Walton Fen, W. of Ramsey; 13, vi, 1913; colld. Hon. N. C. Rothschild. *British Museum Collection.*

Middlesex.—Harefield, N. of Uxbridge; 21, viii, 1916; colld. F. W. Edwards. *British Museum Collection.*

Stanmore; 10, viii, 1918; colld. K. G. Blair. *British Museum Collection.*

Norfolk.—Ormesby, N. of Great Yarmouth. *See F. W. Edwards, under Cambridgeshire records.*

Suffolk.—Tuddenham, N.E. of Newmarket; J. E. Collin. *See F. W. Edwards, under Cambridgeshire records.*

Wales.—Crymlyn Bog, S.W. of Neath, Glamorganshire ; 14, vi, 1900. colld. Lt.-Col. Yerbury. *British Museum Collection.*

Scotland.—Edinburgh. *See F. W. Edwards, under Cambridgeshire records.*

III. OCHLEROTATUS, Arribálzaga.

Ochlerotatus, nov. gen.; F. L. Arribálzaga, 1891, Dipterologia Argentina, in Revista del Museo de La Plata, vol. i, p. 374, and vol. ii, p. 143. Genosyntypes, *Culex albofasciatus* Macquart, and *Ochlerotatus confirmatus*, n. sp. Genolectotype, *O. confirmatus ;* see D. W. Coquillett, 1910, Proc. United States National Museum, vol. xxxvii, p. 577.

1. *Ochlerotatus caspius* (Pallas).

Plate IV., and figs. 20, 25, 28, 30, 47, 51, 59, 105–108.

Culex caspius ; P. S. Pallas, 1771, Reise durch verschiedene Provinzen des Russichen Reichs, p. 475.

Culex punctatus ; J. W. Meigen, 1804, Klassifikazion und Beschreibung der europäischen Zweiflügligen Insekten, vol. i, p. 6.

Culex dorsalis ; J. W. Meigen, 1830, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. vi, p. 242.

Culex penicillaris N.; C. Rondani, 1872, Bull. Soc. Ent. Ital., vol. iv, p. 31 (*fide* J. Villeneuve, 1919, Bull. Soc. Ent. France, p. 56).

Culex pulchripalpis ; F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. ii, p. 16 (*non* Rondani, 1872, Bull. Soc. Ent. Ital., anno. iv, p. 31).

It is impossible, since the type specimen is not available, to be absolutely certain that Pallas' *Culex caspius* is the species generally known as *Ochlerotatus dorsalis* ; but the probabilities are so great that there is justification for reviving this ancient name ; and specimens of *O. dorsalis* from the Caspian are in the British Museum Collection.

The brilliant coloration of the head and thorax, the white bands on the hind tarsi each embracing two tarsal joints, and on the abdomen each embracing two abdominal segments, make *O. caspius* one of the most easily recognisable of British mosquitoes. The great breadth of the light and dark scales of the wings also are characteristic of this species. The larva is to be known from those of other species of *Ochlerotatus* by the length of the pecten, which is about half as long as the siphon, the tufted hair lying beyond the middle of the siphon.

O. caspius appears to be abundant in southern England, and the larva occurs both in inland waters and in brackish water near the sea. In the latter situation it is generally found in company with *O. detritus*. The larvae are found in spring and early summer, and the flies soon appear. In mid-summer neither flies nor larvae are generally seen, and often the breeding-pools are dried up; but when rainy weather fills the pools again, both larvae and flies quickly re-appear, and the flies are often noticed in great abundance at the end of summer and in early autumn. It is not known in what stage *O. caspius* spends the winter. Flies of this species are often found far from any likely breeding-haunts; for instance, one was taken in my garden in Chelsea in August, 1918, at least half-a-mile from any water such as a pond, and nearly a mile from any pond likely to afford a suitable breeding-place. Mr. F. W. Edwards tells me that *O. caspius* has been observed biting indoors. It is seldom that any species of *Ochlerotatus* enters houses.

H. Dyar, L. Howard and F. Knab (1917, The Mosquitoes of North and South America and the West Indies, vol. iv, p. 634), in discussing the possible identity of two American species, *O. onondagensis* (Felt) and *O. curriei* (Coquillett) with *O. caspius* (as *O. dorsalis*), suggest that the sea-side specimens of *O. caspius* are of a different species from those that breed inland in fresh waters, and that an examination of larvae from salt and fresh waters respectively will reveal differences comparable with those of the larval *O. onondagensis* and *O. curriei* in America.[1] Specimens of larval *O. caspius* (probably third instar) from brackish water of Millbrook Common, Southampton, and specimens of the third larval instar from Mitcham Common, Surrey, have been compared by Mr. F. W. Edwards, and some of those from Mitcham Common have comb-scales resembling the Millbrook Common specimens, while others have the terminal spine considerably larger. It is possible that two forms are confused.

O. caspius has been recorded from Scandinavia, Holland, Germany (Berlin), and Austria (see F. V. Theobald, 1901, Monograph of Culicidae or Musquitoes, vol. ii, p. 18); also Southern Russia (Pallas, 1771, *loc. cit.*); it also occurs in Macedonia, whence Major R. A. P.

[1] Dyar and Knab now regard these species as one (1917, Insec. Inscit. Menstruus, vol. v, p. 122).

Hill, R.A.M.C., has sent me specimens, and see J. Waterston, 1918, Bull. Ent. Research, vol. ix, p. 7 ; Palestine ; Mesopotamia, and in Northern Africa (see F. W. Edwards, 1911, Bull. Ent. Research vol. ii, p. 249) ; also France and Italy.

I have gathered the following British records :—

Essex.—Beckton Marshes, London, E. ; iv, 1919 ; colld. F. W. Edwards see F. W. Edwards, 1917, Bull. Ent. Research, vol. vii, p. 217. *British Museum Collection.*

Royal Albert Dock ; colld. Dr. Rees. *See F. V. Theobald* 1901, *A Monograph of the Culicidae or Mosquitoes, vol. ii, p.* [illegible] (recorded as *Culex pulchripalpis* Rondani, and it is suggested that they were introduced on some ships coming from Italian ports—see, however, p. 112).

Hants.—Millbrook Common, N.W. of Southampton ; larvae, 13, ix, 1918, and flies, 13, viii, 1918 ; colld. Corporal Ryan. R.A.M.C. *Received per Capt. M. Gross, R.A.M.C.*

Kent.—Charlton. *See F. W. Edwards,* 1912, *The Entomologist, vol. xlv, p.* 195.

Dartford Marshes ; 29, v, 1902 ; colld. F. W. Edwards. *British Museum Collection.*

Lewisham ; 27, viii, 1899 ; colld. R. S. Pengelly. *British Museum Collection.*

Rochester. *See F. W. Edwards,* 1912, *The Entomologist, vol. xlv, p.* 195.

Middlesex.—Chelsea ; In garden ; Trafalgar Square ; 12, viii, 1918 *Colld. W. D. Lang.*

Chiswick ; 3, ix, 1911 ; colld. F. W. Edwards. *British Museum Collection.*

Stamford Hill, London, N. ; 30, viii, 1899 ; colld. A. Milton. *British Museum Collection.*

Suffolk.—Aldburgh ; 14 and 16, viii, 1895 ; colld. A. Piffard ; see Entomologists' Monthly Magazine, 1895, series 2, vol. vi, p. 227. *British Museum Collection.*

Surrey.—Battersea Park ; 30, vii, 1918. *Colld. Mrs. W. D. Lang.*

Camberwell ; ix, 1918 ; colld. Dr. Simpson. *British Museum Collection.*

Mitcham Common ; larvae colld. Miss L. E. Cheesman, 26, vii, 1918 ; pupated 28 and 29, vii, 1918 ; emerged 1, viii, 1918 ; another emerged (presumably pupating later), 14, viii, 1918. *British Museum Collection.*

Putney ; ix, 1917. *Colld. G. J. Arrow.*

Worcestershire.—Forest of Wyre. *See F. W. Edwards,* 1912, *The Entomologist, vol. xlv, p.* 195.

Wales.—Tal-y-bont, N. of Barmouth, Merionethshire ; reared from larvae ; vii, 1914 ; colld. F. W. Edwards, 1917 ; see Bull. Ent. Research, vol. vii, p. 217. *British Museum Collection.*

2. *Ochlerotatus curriei* (Coquillett).

Culex Curriei, new species ; D. W. Coquillett, 1901, Canadian Entomologist, vol. xxxiii, p. 259.

Ochlerotatus curriei closely resembles *O. caspius*, but the brown coloration of the thorax is not nearly so bright, and the whitish markings form a pair of broad bands instead of taking the form of narrow lines. The wing scales, too, are narrower than those of *O. caspius*, and the light and dark scales are more segregated along separate veins or parts of veins, than uniformly mixed as in *O. caspius* ; thus, longitudinal veins 3 and 5, and the forks of longitudinal vein 4, have dark scales for the most part in *O. curriei*. No British specimens of the larva have been found ; but it closely resembles the larva of *O. caspius*—indeed, no difference between the larvae of these species is discernable from the evidence of the published figures of *O. curriei*.

This species has been added to the British fauna only since last September, when Dr. Hugh Scott took it in numbers in swampy hollows on the heaths S.E. of Wareham, Dorset. On the 15th Sept., 1919, it occurred on Stoborough Heath, "in numbers, biting fiercely, at about 4.30 p.m. (summer time) on a cool, dull, hazy afternoon" ; and on 23rd Sept., Middlebere Heath, "biting, between 12 and 3 p.m. (summer time), in spite of high, rather cold wind, and clouds alternating with hot sunshine." Dr. Scott also noted that none occurred

near the coast north of Studland, between Littlesea Mere and the sea. Specimens are in the Cambridge University Museum and in the British Museum. It also occurs in Denmark, Sweden and N. America.

3. *Ochlerotatus vexans* (Meigen).

Figs. 48, 52, 60, 109.

Culex vexans; J. W. Meigen, 1830, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. vi, p. 241.

Culex sylvestris, n. sp.; F. V. Theobald, 1901, A Monograph of the British Culicidae or Mosquitoes, vol. i, p. 406, pl. xxxv, fig. 138.

Ochlerotatus vexans is known by the very narrow white bands at the basal ends of the hind tarsal joints (fig. 48); otherwise it resembles *O. waterhousei* and *O. annulipes*, but has only dark scales on the wings, and the posterior border of the pale abdominal bands is undulating (fig. 52); the male genitalia, too, are very distinctive (fig. 60). I have not seen a larva, but it has been described and figured by H. Dyar, L. Howard, and F. Knab (Mosquitoes of North and Central America and the West Indies, 1917, vol. iv, p. 695, and 1912, vol. ii, pl. lxvi) as *Aëdes sylvestris*, and may be known from other British species of *Ochlerotatus*, except *O. rusticus*, by the two distal-most teeth of the pecten being widely spaced; and from *O. rusticus* by the tufted hair, which is in a line with the pecten (fig. 109).

O. vexans occurs in Scandinavia, Russia, Austria, Germany and Holland (see F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. i, p. 405), China, Japan, India, Ceylon, Philippines, Borneo, and perhaps Fiji (see F. W. Edwards, 1917, Bull. Ent. Research, vol. vii, pp. 218–9), and (described as *Aëdes sylvestris*) in North America, where it is referred to as a woodland species. It is, apparently, rare in Britain; but F. W. Edwards (Entomologist, 1912, vol. xlv, p. 195) records it from Mildenhall, Suffolk, colld. C. G. Lamb, vii, 1804; and since then he tells me he has seen specimens from Shotover, near Oxford (colld. A. H. Hamm, 5, viii, 1918, two males), and from Coe Fen, Cambridge (colld. F. Jenkinson, one female).

There are, in the British Museum Collection, some specimens from the Clifton Collection, which, though without information as to locality, are probably British.

4. *Ochlerotatus waterhousei* (Theobald).

Figs. 49, 53, 61, 110.

Culex Waterhousei, sp. n.; F. V. Theobald, in C. O. Waterhouse, 1905, Annals and Magazine of Nat. Hist., series 7, vol. xvi, p. 674.

Ochlerotatus waterhousei and *O. annulipes* are very much alike, and the differences given in the tables above (pp. 40, 42–3), and in figs. 49–50, 61–2, must be referred to for distinguishing them. The larva of *O. waterhousei* may be distinguished from that of *O. caspius* by the length of the pecten; from *O. rusticus* by the position of the tufted hair; from *O. vexans* by the spacing of the last two teeth of the pecten; from *O. detritus* by the number of teeth in the pecten; from *O. nemorosus* by the length of the anal gills; and from *O. annulipes* by the length of the pecten-teeth (fig. 110; see, however, footnote on p. 63).

O. waterhousei has been so confused with *O. annulipes* (see under that species) that it is not possible to determine its range with certainty. Probably it is not so common in continental Europe as *O. annulipes* (which is the common form in France, see J. Villeneuve, 1919, Bull. Soc. Ent. France, p. 56, as *Culex cantans*). In England, F. W. Edwards (1912, The Entomologist, vol. xlv, p. 218, as *Ochlerotatus maculatus*) refers to it as widely distributed and probably common. The larvae are found in early summer (in shadiest pools in thick woods—F. W. Edwards); and the fly generally towards midsummer. It is not known in what stage the winter is spent. The following are some records of its occurrence:—

Bucks.—Burnham Beeches; 7, v, 1912, colld. F. W. Edwards; 10 and 28, vi, 1907, 18, vi, 1908 (larvae and pupae); colld. C. O. Waterhouse. *British Museum Collection.*

Essex.—Epping Forest; larva *colld. Miss L. E. Cheesman*, v, 1918; pupated 15, v, emerged 19, v; fly *colld. H. Main*; v, 1918; see p. 110.

Hants.—Brockenhurst; 5 and 16, v, 1904; 5 and 7, v, 1905; pupae and flies; colld. C. O. Waterhouse. *British Museum Collection.*

Herts.—Bushey Heath; 27, vii, 1912; colld. F. W. Edwards. *British Museum Collection.*

Felden, S. of Boxmoor; 7, v, 1899; colld. A. Piffard. *British Museum Collection.*

Knebworth ; iv, 1919 ; larvae ; colld. F. W. Edwards. *British Museum Collection.*

Hunts.—Wood Walton Fen, W. of Ramsey ; 13–15. iv. 1914 ; colld. F. W. Edwards. *British Museum Collection.*

Kent.—Hever, W. of Tonbridge ; 8, vii, 1907 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Middlesex.—Nower Hill, Pinner ; i. v. 1914 ; colld. F. W. Edwards. *British Museum Collection.*

Norfolk.—Merton, S. of Walton ; 31, v, 1908 and 10, vi, 1900 ; colld. Lord Walsingham. *British Museum Collection.*

Shropshire.—Longner Hall, S.E. Shrewsbury ; in garden ; v. 1918. vi, 1908 and 12, x, 1912 ; colld. R. F. Burton. *British Museum Collection.*

Suffolk.—Barton Mills ; v. 1916 ; colld. F. W. Edwards. *British Museum Collection.*

Sussex.—Angmering Ponds, S.E. of Arundel ; 1 and 27, vii, 1907 ; colld. Rev. A. E. Eaton. *British Museum Collection.*

Eridge, S. of Tunbridge Wells, Kent ; 11, vi, 1886 ; colld. G. H. Verrall. *British Museum Collection.*

Goring Woods, N.W. of Worthing ; 20, 24 and 26. vi. 1907 ; colld. Rev. A. E. Eaton. *British Museum Collection.*

Scotland.—Dingwall, Ross ; 29, v, 1911 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

5. *Ochlerotatus annulipes* (Meigen).

Figs. 50, 54, 62, 111.

Culex annulipes ; J. W. Meigen, 1830, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. vi, p. 241.

? *Culex variegatus ;* F. de P. Schrank, 1781, Enumeratio Insectorum Austriae indigenorum, p. 482.

? *Culex maculatus* ; J. W. Meigen, 1804, Klassifikation und Beschreibung der europäischen Zweiflügligen Insekten, vol. i, p. 4.

? *Culex cantans*, Hoffmgg. ; J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 6. [Note Meigen, in ascribing this species to Hoffmannsegg, is probably only quoting an MS. label of that collector's writing.]

Mr. F. W. Edwards has kindly pointed out to me that Meigen's description of *Culex cantans* agrees far more closely with his later description of *Culex annulipes* than with *Ochlerotatus waterhousei*, the species generally hitherto considered as identical with Meigen's *Culex cantans*. Probably, then, *Culex annulipes* and *Culex cantans* are the same species. Now, Meigen states that his *Culex maculatus* is identical with his *C. cantans* ; in fact, is only the male of that species (1830, *loc. cit.*) ; but since, the name *maculatus* has the priority over *cantans*, this species must be known as *Ochlerotatus maculatus*, Meigen, with the synonymy given above ; and the species which has generally been called *Ochlerotatus maculatus* must be called *O. waterhousei*, Theobald. But, until the identity of *Culex annulipes* with *C. cantans* is proved, it is best to retain the former name and drop *C. maculatus*. *O. annulipes* is unlikely to be mistaken for any other species except *O. waterhousei*, which it so closely resembles, that the differences described on pp. 40, 42–3 must be looked for. The larvae, too, are so similar to those of *O. waterhousei*, that a satisfactory difference has yet to be found. Note, too, the relative situations in which the larvae are found ; those of *O. waterhousei* in the shadiest pools of thick woods, and those of *O. annulipes* in open pools. *O. annulipes* is probably common on the European continent ; in England it appears to be local. Specimens have been found in the following places :—

Hunts.—Wood Walton Fen, W. of Ramsey. 29, v, 1913 ; colld. Hon. N. C. Rothschild ; and 13–15, iv, 1914, and 17, iv, 1919, larvae, pupae and flies ; colld. F. W. Edwards ; the larvae were taken from "clear pools under birch and sallow trees" and "clear puddles among reeds" (see F. W. Edwards, 1917, Bull. Ent. Research, vol. vii, p. 215). *British Museum Collection.*

Norfolk.—Rollesby, N. of Great Yarmouth ; colld. G. H. Verrall. *See F. W. Edwards*, 1912, *The Entomologist, vol. xlv, p.* 217.

Shropshire.—Longner Hall, S.E. of Shrewsbury ; one specimen ; vi, 1918 ; colld. R F. Burton. *British Museum Collection.*

Sussex.—Angmering Ponds, S.E. of Arundel ; 1 and 27, vii, 1907 ; colld. Rev. A. E. Eaton. *British Museum Collection.*

Rotherfield, S. of Tunbridge Wells, Kent ; 6, vi, 1886 ; colld. G. H. Verrall. *British Museum Collection.*

6. *Ochlerotatus detritus* (Haliday)

Figs. 55, 63, 67, 121, 122.

Culex detritus; A. H. Haliday, 1833, Entomological Magazine, vol. i, p. 151.
Culex salinus, sp. n.; E. Ficalbi, 1896, Bull. Soc. Entomologica Italiana, anno xxviii, p. 29.
Culex Terrici, n. sp.; F. V. Theobald, 1903, A Monograph of the Culicidæ or Mosquitoes, vol. iii, p. 193.

Ochlerotatus detritus is distinguished by the white scales that are freely scattered over its wings, abdomen and proximal parts of the legs; otherwise, it has a blackish ground-colour with pale basal abdominal rings. The light-and-dark speckled wings distinguish it from *O. nemorosus*, which it otherwise closely resembles and whose wings are nearly entirely dark-scaled (figs. 67–8); the speckling of light scales on the darker parts of the abdomen above and the rows of black spots beneath[1] also distinguish it from *O. nemorosus* (figs. 55, 60), and the male genitalia of the two species are very different in detail (figs. 63–4). The larva is remarkable among the species of *Ochlerotatus* for the shortness of its siphon and the numerous small denticles on the proximal part of the pecten-teeth (figs. 121–2). Other details are mentioned in the former section.

O. detritus occurs in Italy (see reference above), and there are in the British Museum Collection specimens from Majorca and Algeria. It is abundant in brackish water in the South of England, and has been taken in Wales and Ireland; and *O. caspius* is nearly always found in company with it; on the other hand, it does not accompany *O. caspius* where that species is found breeding inland. It is probable that *O. detritus* winters as a larva or an egg, since larvae are found early in the year, and after that the flies. The species is, at least, double-brooded, for larvae and emerging flies have been taken in September. Probably, as with *O. nemorosus*, in summer droughts the shallow waters where they breed dry up, and the impregnated female flies tide over the dry period among vegetation. In May, 1918, at Great Wakering, Essex, an interesting observation was made by

[1] The "[illegible] of Haliday's [illegible]. This, and the sea-side habitat make it possible to identify certainly Haliday's [illegible] with Theobald's *C. salinus*.

Mr. A. J. Grove, who found males of this species swarming in company with males of *Anopheles bifurcatus*.

The following are British records of *Ochlerotatus detritus* :—

Cornwall.—Sheviock, S. of St. Germans ; 7, ix, 1912 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Devon.—Tor Point, S. Devon ; 19, iv, 1889 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Essex.—Beckton Marsh, near Royal Albert Dock ; 16, iv, 1914 ; colld. F. W. Edwards. *British Museum Collection.*

Great Wakering, S.E. of Rochford ; v, 1918 ; males swarming with males of *Anopheles bifurcatus*. *Colld. A. J. Grove.*

Walton-on-Naze ; 4 and 5, v, 1907 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Hants.—Millbrook Marsh, N.W. of Southampton ; larvae and flies ; 8 and 13, viii, 1918, and 13, ix, 1918 ; colld. Corporal Ryan. *Per Capt. M. Gross, R.A.M.C.*

Kent.—Dartford ; 14, vi, 1912 ; colld. Lt.-Col. Yerbury ; also the type-locality of *Culex terriei* (a synonym of *Ochlerotatus detritus*), see F. V. Theobald, 1903, A Monograph of the Culicidae or Mosquitoes, vol. iii, p. 194. *British Museum Collection.*

Sheerness district ; larvae ; 22, iii, 1918, and 2, iv, 1918 ; and flies, 8, v, 1918. *Colld. Major A. Macdonald, R.A.M.C.*

Sussex.—Worthing ; 16 and 26, v, 1907, and 8, vi, 1907 ; colld. Rev. A. E. Eaton. *British Museum Collection.*

Wales.—Tal-y-bont, N. of Barmouth, Merionethshire ; larvae (in puddle behind shingle bank) and flies ; vii, 1914 ; colld. F. W. Edwards. *British Museum Collection.*

Scotland.—Arrochar, Dumbarton ; ix, 1915 ; larvae in brackish water pools, full of decayed seaweed, reached on occasions by the tide ; colld. Miss L. H. Huie. *British Museum Collection.*

Brodrick, Arran ; v, 1919 ; brackish pools. *Colld. F. W. Edwards.*

Ireland.—Holywood, Co. Down, N.E. of Belfast ; colld. A. H. Haliday. *See original description.*

Sutton, near Dublin. *Per Dr. R. F. Scharff.*

7. *Ochlerotatus nemorosus* (Meigen).

Plate V., and figs. 9, 56, 64, 68, 113–116.

Culex nemorosus: J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 4.

Culex sylvaticus; J. W. Meigen, 1818, *op. cit.* p. 6 (*non Culex sylvaticus*, J. F. Stephens, 1825, Zool. Journ., vol. i, p. 454, which is *Culex pipiens*, see F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277).

Culex domesticus (*partim*); J. F. Stephens, 1825, Zoological Journal, vol. i, p. 455; from Hertford (*non Culex domesticus*; E. Germar, 1817. Reise nach Dalmatien und in das Gebeit von Ragusa, p. 290). The specimens so named in Stephen's collection in the British Museum are *C. pipiens*, and one *C. nemorosus*.

? *Culex concinnus*; J. F. Stephens, 1846, Illustrations of British Entomology, Supplement, p. 19, pl. xliii, fig. 1. (See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

? *Culex fusculus*; J. W. Zetterstedt, 1850, Diptera Scandinaviae, vol. ix, p. 3459.

? *Culex nigripes*, Zetterstedt, var. *sylvae*; F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. ii, p. 96.

Culex concinnus of Stephens is either a variety of *Ochlerotatus nemorosus* (Meigen) or, probably, a distinct species. The general ground-colour of the type-specimen is darker, the dorsal surface of the thorax is grey at the sides, the colour of the abdominal rings is paler, and it is of a smaller size than *O. nemorosus*. *Culex nigripes* var. *sylvae* of Theobald agrees closely with *Culex concinnus*.

Ochlerotatus nemorosus resembles *O. detritus*, but has few, if any, pale scales on the wings and on the darker parts of the abdomen above, and the abdomen is not spotted beneath. The pale transverse bands on the abdomen are whitish rather than yellowish, and do not tend to spread medianly to form a longitudinal band in the mid-line, as in *O. rusticus*. The male genitalia also are very peculiar (see fig. 64). The larva is remarkable for the great size of the anal gills, which taper to a fine point and are not sausage-shaped, as in *Finlaya geniculata*, which also has very large anal gills; their size, however, varies.

Hermaphrodite specimens have been described by Edwards (1917, Bull. Ent. Research, vol. vii, p. 216), taken on Harrow Weald Common, and first noticed by him because apparently he was being bitten by a male.

Ochlerotatus nemorosus is a more or less sylvan species, frequenting the neighbourhood of woods and copses, and biting freely by day. It is found throughout central Europe. The Algerian record (F. W. Edwards, 1911, Bull. Ent. Res., vol. ii, p. 248) is *O. detritus*. It is common in Britain. The larvae appear to occur especially in shallow pools on commons and heaths near woody places, where the bottom is composed of rotting leaves. In such waters they are found in spring, having hibernated in this stage ; and, since these pools readily dry up, the larvae are not met with in fine summers, and do not appear again until the rainy weather at the end of summer or in the early autumn. Then the pools are quickly re-stocked with larvae. But if, as in 1918, the dried-up pools are re-filled at mid-summer, a brood of larvae are soon produced (see evidence of records in 1918 and Edward's observations, 1917, Bull. Ent. Research, vol. vii, p. 216). It is almost certain that the impregnated females tide over the droughts among the herbage in woods.

Some British records are as follows :—

Bucks.—Burnham Beeches ; 7, v, 1912 ; colld. F. W. Edwards. *British Museum Collection.*

Farnham Common, near Burnham Beeches ; 7, v, 1912 ; colld. F. W. Edwards. *British Museum Collection.*

Dorset.—Littlesea, Studland ; 31, vii, 1911 ; colld. Rev. A. E. Eaton ; 8, 12, 18, and 21, v, 1907, and 2, vi, 1912 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Rempstone Heath, W. of Studland ; 30, v, 1907 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Essex.—Coopersale Common, N.E. of Epping ; larvae ; 6, viii, 1918. *Colld. D. J. Scourfield.*

Epping Forest ; larvae ; emerged, 21 and 22, iv, 1918 ; another larva pupated, 25, iv, and emerged, 29, iv, 1918 ; *colld. Lt. Tickner Edwardes, R.A.M.C.* ; also 4 and 6, v, 1918. *Colld. K. G. Blair* ; also 30, vii, 1919. *Colld. F. W. Edwards.*

Epping Forest, Chigwell Row Recreation Ground ; larvae ; 1 viii, 1918. *Colld. D. J. Scourfield.*

Epping Forest, Monk Wood ; 31, iii, 1918. *Colld. A. Bacot.*

Loughton ; larvae from sheltered pool, full and teeming with

larvae of *O. nemorosus* at beginning of May, then dried up, and again teeming at end of July when again filled. 28, vii. 1918. *Colld. Miss L. E. Cheesman.*

Hants.—Southampton; larvae and flies; received 2, v, 1918. *Colld. Major A. C. Parsons, R.A.M.C.*

Lyndhurst; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Middlesex.—Hampstead Heath; larvae, in company with larvae of *Culex pipiens*, in temporary pool under trees, with leaves at bottom; 28, vii, 1918. *Colld. K. G. Blair.*

Harrow Weald Common; 21, iv, 1912 (see F. W. Edwards, 1917, Bull. Ent. Research, vol. vii, p. 216); colld. F. W. Edwards. *British Museum Collection.*

Stanmore; larvae; 20, iv, 1918. *Colld. K. G. Blair.*

Stanmore Common; 18, v, 1916; colld. F. W. Edwards. *British Museum Collection.*

Shropshire.—Longner Hall, S.E. of Shrewsbury; 1, v, 1912, and 16, v, 1918; colld. R. F. Burton. *British Museum Collection.*

Surrey.—Oxshott; 28, v, 1902; colld. C. O. Waterhouse. *British Museum Collection.*

Putney; 16, v. 1906; fly and larva; colld. C. O. Waterhouse. *British Museum Collection.*

Sheen Common; larvae in a pool recently filled after being dry since the spring, when larvae of this species were present in it; 21, vii, 1918. *Colld. R. H. Thomas.*

Scotland.—Nethy Bridge, S.W. of Grantown, Aberdeenshire; colld. Nuttall. *British Museum Collection.*

North Sutor, Cromarty; 12, vi, 1894; colld. O. Grant. *British Museum Collection.*

The Mound, N.W. of Dornoch, Sutherland; 4, viii, 1900; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Pitlochry; Perthshire; 4, ix, 1915; colld. P. A. Buxton. *Cambridge University Museum Collection.*

Torphins, Aberdeenshire, W. of Aberdeen and N.E. of Aboyne colld. J. M. Wright, B.M. *British Museum Collection.*

8. *Ochlerotatus rusticus* (Rossi).

Figs. 57, 65, 112.

Culex rusticus; P. Rossi, 1790, Fauna Etrusca, vol. ii, p. 333.

Culex ornatus (partim); J. F. Stephens, 1825, Zoological Journal, vol. i, p. 454. (*non Culex ornatus*, Hoffmgg.; J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, p. 5. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

Culex pungens, R.D.; J. B. Robineau-Desvoidy, 1827, Mem. Soc. Hist. Nat., Paris, vol. iii, p. 407.

Culex quadratimaculatus, Nob.; M. Macquart, 1834, Histoire Naturelle des Insectes; Diptères, vol. i, p. 34.

Culex diversus, n. sp.; F. V. Theobald, 1901, Monograph of the Culicidae or Mosquitoes, vol. ii, p. 73, pl. xxvii, fig. 107.

Culex nemorosus, Meigen, var. *luteovittata*, mihi.; F. V. Theobald, 1901. *tom. cit.*, p. 85.

Ochlerotatus rusticus, though generally resembling *O. nemorosus*, is really a very distinct species. The yellow colour of the pale abdominal markings, and their tendency to spread medianly so as to form a line down the middle of the abdomen (fig. 57), readily distinguishes *O. rusticus* from *O. nemorosus*. But the male genitalia of *O. rusticus* (fig. 65) differ so much from those of the other British species of *Ochlerotatus*, that they may often be distinguished by the naked eye, mainly owing to their dense hairiness. The siphon of the larval *O. rusticus* differs from that of its British congeners in the position of the tufted hair, in the possession of a minute second tufted hair, and in having several single hairs scattered over its dorsal surface (fig. 112). It also shares with *O. vexans* the peculiarity of the widely-spaced last two pecten-teeth. *O. rusticus* does not appear to be a well-known species. It was originally described from Tuscany, and specimens from Ghent are in the British Museum Collection. It occurs in Denmark (C. Wesenberg-Lund) and Macedonia (J. Waterston). In Britain it seems to be widely-distributed, and replaces *O. nemorosus* in some districts. The following are some records of *O. rusticus* from Britain:—

Hants.—Brockenhurst; i, v, 1905 (type of *Culex nemorosus* var. *luteovittata*); larvae and flies, 26, 27 and 29, iv, 1905; fly, 5, v, 1904; colld. C. O. Waterhouse. *British Museum Collection.*

Lyndhurst; 21, v, 1904; colld. G. H. Verrall. *British Museum Collection.*

Herts.—Felden, S. of Boxmoor; 7, v, 1899; colld. A. Piffard. *British Museum Collection.*

Kent.—Hythe; 13, vi, 1899; colld. A. Piffard. *British Museum Collection.*

Sheerness district; larvae; 20, iii, 1918. *Colld. Major A. Macdonald, R.A.M.C.*

Tunbridge Wells; 5, vi, 1886; colld. G. H. Verrall. *British Museum Collection.*

Norfolk.—Merton, S. of Walton; 30, vi, 1907; colld. Lord Walsingham *British Museum Collection.*

Shropshire.—Longner Hall, S.E. of Shrewsbury; in garden, vi, 1904, ♂♂, lurking among *Scilla nutans*, 5, v, 1918; ♀♀, 13, v, 1918; colld. R. F. Burton. *British Museum Collection.*

Sussex.—Goring Woods, N.W. of Worthing; 24 and 29, vi, 1907; colld. Rev. A. E. Eaton. *British Museum Collection.*

Tilgate, Sussex; 23, v, 1897; colld. G. H. Verrall. *British Museum Collection.*

Warwickshire.—Brinklow, N.W. of Rugby; 30, vi, 1902; colld. Major E. E. Austen, D.S.O. *British Museum Collection.*

Wales.—Porthcawl, S.W. of Bridgend, Glamorganshire; 31, v, 1906; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Locality not specified.—See G. H. Verrall, 1901, A list of British Diptera, second edition, p. 13 (as *Culex rusticus*).

IV. FINLAYA. Theobald.

Finlaya, nov. gen.: F. V. Theobald, 1903, A Monograph of the Culicidae or Mosquitoes, vol. iii, p. 281. Genosyntypes, *F. poicilia*, n. sp., and *Culex Kochi*, Donitz. Genolectotype, *Finlaya poicilia*. Theobald (see H. Dyar, L. Howard, and F. Knab, 1917, The Mosquitoes of North and South America and the West Indies, vol. iv, p. 611).

1. *Finlaya geniculata* (Olivier).

Figs. 58, 69, 104, 117–120.

Culex geniculatus; G. A. Olivier, 1791, Encyclopédie Méthodique, Histoire Naturelle, Insectes, vol. vi, p. 134.

Culex lateralis, Meg.; J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 5. [Note: "Meg." = Megerle von Mühlfeldt, and is but the author of the name in MS.]

Culex ornatus (*partim*); J. F. Stephens, 1825, Zoological Journal, vol. i, p. 454; Hertford. (*non Culex ornatus*, Hoffmgg.; J. W. Meigen, 1818, *op. cit.*, p. 5. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

Culex guttatus; J. Curtis, 1834, British Entomology, vol. viii, p. 537, pl. 537 (but not fig. 9); Cobham, Surrey.

Culex albo-punctatus, N.; C. Rondani, 1872, Bull. Soc. Entom. Italiana, anno iv, p. 31.

Finlaya geniculata is an easily recognised species. Its black ground-colour, with brilliant white knee-spots and triangular lateral spots on the abdomen, as well as the very pale greenish-yellow markings on the thorax, mark it distinctly from other British species. The larva, too, is very distinct if the "comb" of the eight abdominal segment can be seen; for the scales of which it is composed form a single line, as in all the larval instar of the British species of *Anopheles* and *Aëdes* and in the first larval instar of *Theobaldia annulata*, *Culex pipiens*, *Ochlerotatus caspius*, *O. nemorosus* and, probably, of all Culicines. In the species of *Ochlerotatus* the scales of the "comb," in all but the first instar, are irregularly arranged. The teeth of the pecten of *Finlaya geniculata* are comparatively few, and straighter than in the species of *Ochlerotatus*. The pecten is comparatively short; and the anal gills are very long and sausage-shaped.

Finlaya geniculata is a thoroughly sylvan species, and its larva lives, like that of *Anopheles plumbeus* (and often in company with it), in water-filled holes in trees.[1] Mr. Burton, of Longner Hall, Shrewsbury, has kept through the following winter, in a wooden tub, eggs which were laid in the autumn of 1917; also a few larvae which hatched before the winter survived. In the spring of 1918 the eggs hatched, and the larvae, with those that had passed through the winter, completed their metamorphosis and emerged as flies in April. This species, therefore, passes the winter as a larva or in the egg;

[1] Generally Beech-trees, but it has been found in Hornbeam, Chestnut, Sycamore, and Ash (F. W. Edwards), and probably occurs in any tree having suitable water-filled holes. It is found also with *Orthopodomyia* and *Stegomyia*, see p. 110.

and it is probable that the species of the allied genus *Ochlerotatus* do the same. It is also probable, judging from the respective dates at which the flies and larvae of various sizes have been found, and from the observations (though few) on the slow rate of growth of the larvae, that normally there is only one brood of *Finlaya geniculata* in the year. Such is not always the case in *Ochlerotatus*, for *O. caspius*, *O. detritus* and *O. nemorosus*, except in dry years, have at least two broods.

Finlaya geniculata is recorded from Austria, Russia, and Switzerland (see F. V. Theobald, A Monograph of the Culicidae or Mosquitoes, 1901, vol. ii, p. 53, and 1903, vol. iii, p. 191, as *Culex lateralis*). specimens, too, from France (Alpes Maritimes) are in the British Museum Collection; it also occurs in Denmark and Macedonia. The following are some British records :—

Bucks.—Burnham Beeches: (1) 10 and 28, vi, 1907; colld. C. O. Waterhouse; (2) larvae and pupae associated with larvae of *Anopheles plumbeus* in holes in beech trees, 4, iv, 1916; pupated 18, iv, emerged 24, iv; pupated 24, iv, emerged 30, iv; pupated 28, iv, emerged 4, v; pupated 30, iv, emerged 4, v; colld. F. W. Edwards. See F. W. Edwards, 1917, Bull. Ent. Research, vol. vii, p. 212. *British Museum Collection.*

Cambs.—Cambridge, in bathroom of Livingstone Hotel; 20, viii, 1910; colld. C. B. Holman-Hunt. *Cambridge University Museum Collection.*

Cornwall.—Poltesco, N. of Ruan Minor, Lizard district; 27, v, 1912; colld. Rev. A. E. Eaton. *British Museum Collection.*

Scilly; vi, 1919. *Colld. K. G. Blair.*

Essex.—Epping Forest: (1) Epping Thicks: larvae in hollows on tree-bases; viii, 1918; *colld. D. J. Scourfield*; (2) Loughton: larvae; *colld. A. W. Bacot*; 10, iv, 1918, pupated 1, v, and emerged 9, v; (3) Monkswood; larvae in hollows on tree-bases; *colld. D. J. Scourfield*, viii, 1918.

Hants.—Gosport; 22, vii, 1892; colld. M. K. Thomas. *British Museum Collection.*

Herts.—Bushey Heath; 27, vii, 1912; colld. F. W. Edwards. *British Museum Collection.*

Cassiobury Park, N. of Watford ; young larvae associated with larvae of *Anopheles plumbeus* in hole at base of beech tree ; 21, viii, 1916 ; colld. F. W. Edwards. *See Bull. Ent. Research*, 1917, *vol. viii, pp.* 201, 212.

Kent.—Dartford ; 14, vi, 1912 ; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Middlesex.—Bedford Park, Chiswick ; 17, vi, 1918. *Colld. Dr. C. J. Gahan.*

Harrow ; 17, vi, 1914 ; colld. F. W. Edwards. *British Museum Collection.*

Regent's Park, London, N.W. ; 4, viii, 1915 ; colld. F. W. Edwards, *British Museum Collection.*

Oxon.—Stokenchurch ; 13, viii, 1907 ; colld. G. H. Verrall. *British Museum Collection.*

Shropshire.—Longner Hall, S.E. of Shrewsbury ; 31, v, 1908, and 5, viii, 1918 ; flies ; see also record above of eggs and larvae ; colld. R. F. Burton. *British Museum Collection.*

V. TAENIORHYNCHUS, Arribálzaga.

Taeniorhynchus, nov. gen. ; F. L. Arribálzaga, 1891, Dipterologia Argentina, 1 ; Revista del Museo de la Plata, vol. i, p. 374, and vol. ii, p. 147. Genosyntypes, *Culex taeniorhynchus*, Arribálzaga, non Wiedemann, *Taeniorhynchus confinnis*, n. sp., and *Taeniorhynchus fasciolatus*, n. sp. Genolectotype, *Culex titillans* F. Walker, in J. E. Gray, 1848, List of the specimens of Dipterous Insects in the collection of the British Museum, part i, p. 5 (= *Culex taeniorhynchus* Arribálzaga, non Wiedemann).

1. *Taeniorhynchus richiardii* (Ficalbi).

Figs. 24, 26, 35, 38, 74.

Culex Richiardii, n. sp. ; E. Ficalbi, 1889, Bull. Soc. Ent. Italiana, vol. xxi, p. 50.

Taeniorhynchus richiardii is easily distinguished from all British gnats except *Theobaldia annulata* by having a pale ring in the middle of the first tarsal joint of the hind leg. And the wings, speckled with very broad scales, dark mixed with light, render it very easily distinguished from *Theobaldia annulata*. The most remarkable feature,

however, in *Taeniorhynchus richiardii* is the siphon of the larva, which not only has no pecten, but is of a peculiar shape, the true siphon being exceedingly short, and its apparently pointed tapering end being formed of the ventral pair of the valves that in a normal siphon close the aperture. The siphon is adapted for piercing the stems of submerged plants,[1] and for exploiting the air contained in them and thus obviating the necessity of periodic journeys to the surface for breath. Edwards has observed that this species spends the winter as a nearly full-grown larva.[2] The pupa also is adapted to a submerged life, and pierces the roots of grass with its pointed thoracic trumpets. The fly appears about midsummer, and though widely distributed, does not seem to be very common. It was originally described from Italy; specimens from Palestine are in the British Museum Collection; and Waterston records it from Macedonia (Bull. Ent. Research, 1918, vol. ix, p. 8). British records are as follows:

Cambs.—Wicken, N.E. of Cambridge; 2, vii, 1915; colld. F. W. Edwards. *British Museum Collection.*

Dorset. Littlesea, Studland; 2, viii, 1911; colld. Rev. E. A. Eaton. *British Museum Collection.*

Durham.—Gibside, S.W. of Gateshead; 10, viii, 1916; colld. R. S. Bagnall. *British Museum Collection.*

Hants.—Church Farm, near Hook, E. of Basingstoke, Hants.; 17, vii, 1912; colld. F. W. Edwards. *British Museum Collection.*

Herts.—Letchworth; larvae. *Colld. F. W. Edwards; Jan.* 1910.

Kent.—Dymchurch, S.W. of Hythe; in an outhouse, with females of *Anopheles maculipennis*, 25, vii, 1918. *Colld. G. Walton.*

Wye, N.E. of Ashford; indoors; colld. Theobald. *See F. V. Theobald,* 1903, *A Monograph of the Culicidae or Mosquitoes, vol. iii, p.* 260.

Middlesex. Ealing; 20, vii, 1912; colld. H. Campion. *British Museum Collection.*

[1] *Glyceria fluitans*: see F. W. Edwards, 1919, [illegible] and *Typha*; see C. Wesenberg-Lund, 1918, [illegible].

[2] For a detailed account of this larva, see F. W. Edwards, 1919, Entomologist's Monthly Magazine, series 3, vol. v, p. 83. Also, C. Wesenberg-Lund, 1918, Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening in Kjøbenhavn, [illegible].

Norfolk.—Norwich and the Norfolk Broads; obs. Dr. Long. *See F. V. Theobald,* 1903, *A Monograph of the Culicidae or Mosquitoes, vol. iii, p.* 269.

Shropshire.—Longner Hall, S.E. of Shrewsbury; 30, vii, 1918. *Colld. R. F. Burton.*

Sussex.—Angmering Ponds, S.E. of Arundel; colld. Rev. A. E. Eaton. *See F. W. Edwards,* 1912, *The Entomologist, vol. xlv, p.* 261.

Patching Pond, N.W. of Worthing; 9, ix, 1907; colld. Rev. A. E. Eaton. *British Museum Collection.*

Warwickshire.—Sutton Coldfield; colld. R. C. Bradley. *See F. W. Edwards,* 1912, *The Entomologist, vol. xlv, p.* 261.

VI. THEOBALDIA, Neveu-Lemaire.

Theobaldia, nov. gen.; M. Neveu-Lemaire, 1902, Comptes Rendus Heb. des Séances et Mémoires de la Soc. de Biologie, vol. liv, pp. 1331–2. Genotype, *Culex annulatus,* Schrank.

1. *Theobaldia annulata* (Schrank).

Figs. 8, 21, 33, 36, 76, 123–5.

Culex annulatus; F. v. P. Schrank, 1776, Beyträge zur Naturgeschichte, p. 97.

Culex affinis, Mihi; J. F. Stephens, 1825, Zool. Journ., vol. i, p. 452; Hertford; in June.

Culex calopus; J. F. Stephens, 1825, *loc. cit.;* near London (*non Culex calopus,* Hoffmgg.; J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 3). Specimens thus labelled in Stephens' Collection in British Museum.

Theobaldia annulata is one of the commonest and most easily distinguished of British gnats. Its great size, boldly-contrasted black and pale-cream colouring, as well as its domestic habits, force it upon the attention. With *Anopheles maculipennis* it is known from all other British species by having spots on the wings. They are formed by the aggregation of dark scales. From *A. maculipennis* it may be known by its burly build, as well as by its banded legs and abdomen. *Culicella morsitans* and *C. fumipennis* also have a tendency for the aggregation of wing-scales into spots, but this is only a tendency, and the characters given on p. 30 indicate how these two species can

easily be distinguished from *Theobaldia annulata*. The larvae of the two species of *Culicella*, and that of *Theobaldia annulata*, differ from the larvae of other species of British gnats in the position of the tuft of hair at the proximal end of the siphon instead of near the middle. And the pecten-teeth of *T. annulata*, produced into hair-like terminations, distinguish the larva of this species from those of *Culicella morsitans* and *C. fumipennis* (figs. 76, 123–5).

Theobaldia annulata, like *Anopheles maculipennis* and *Culex pipiens* (and often in company with these), winters as a female fly in cellars, outhouses, etc.; and may be troublesome in mild weather in the winter, by becoming active owing to the warmth and biting in the house. It is possible that in exceptionally mild winters some larvae may survive, since they have been recorded at dates very late in the year. Some eggs which hatched in captivity in the British Museum on 2nd Sept., 1918, passed through several instar, but most died before the fourth instar was attained, and none pupated. Their death, however, may have been due to unnatural conditions or unsuitable food. On the other hand, some very young larval *Anopheles plumbeus*, taken in Epping Forest and Culross, Fifeshire, in late summer, 1918, having attained the fourth larval instar are still alive at the present time (Feb. 1919). Larval *Theobaldia annulata* is sometimes found with *Culex pipiens* in water-butts; and, as far as I am aware, these are the only British species which are found in what may be called domestic waters.

Theobaldia annulata occurs throughout Europe, in N. Africa, and in Mesopotamia there is a variety apparently adapted to desert conditions, the white scales becoming yellow, and the black scales brown. The American records probably refer to *T. maccrackenae* and *T. dugesi* (see H. Dyar, L. Howard and F. Knab, 1915, Mosquitoes of N. of Central America and the West Indies, vol. iii, pp. 494 and 466). Specimens in the British Museum Collection have been obtained from Norway, Switzerland, Southern France, Cyprus, and Morocco. Miss A. L. Lang has sent me a specimen from Monastir; Mr. Waterston records it from Mikra in the Salonica district (Bull. Ent. Research, 1918, vol. ix, p. 90); and Major E. E. Austen, 1920, tells me he met with one specimen in Palestine.

In Britain the species has been collected from so many localities

that it would serve no purpose to enumerate them. But it is worth noting that specimens from as far north as Inverness-shire and Aberdeen are in the British Museum Collection.

VII. CULICELLA, Felt.

Culicella, n. gen.; E. P. Felt, 1904, New York State Museum Bulletin 79, p. 391c. Genotype, *Culex dyari*, Coquillett.

1. *Culicella morsitans* (Theobald).

Figs. 23, 31, 34, 37, 39, 69, 71, 77.

Culex morsitans, n. sp.: F. V. Theobald, 1901, Monograph of the Culicidae, vol. ii, p. 8, pl. xx, fig. 79.

? *Culex dyari*, sp. nov.; D. W. Coquillett, 1902, Journ. New York Ent. Soc. vol. x, p. 192.

Culicella morsitans and *C. fumipennis* are very similar species hardly to be distinguished as flies, but having quite distinct larvae. The blunt abdomen, the short first hind-tarsal joints, and nearness of the posterior cross-vein to the other cross-veins characterise these two species of *Culicella* and separate them from the other British gnats except *Theobaldia annulata*. That species, however, besides having spotted wings, has a median pale longitudinal band on the second abdominal segment and the posterior cross-vein almost in a line with the mid cross-vein, characters not possessed either by *Culicella morsitans* or *C. fumipennis*. In *C. morsitans* there are very few, if any, white scales on the proboscis of the female (fig. 69), and in the male the first fore-tarsal joint is decidedly longer than the remaining four joints; the pattern, too, on the underside of the male abdomen is generally diffused rather than clearly marked (fig. 71). In the larva (fig. 77) the axis of the pecten is nearly parallel with that of the siphon, and there are no single scattered spines on the siphon as there are in *C. fumipennis*, the axis of whose pecten is oblique with that of the siphon. (Note: The siphons of the two species are figured by F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 262, figs. 3, 4, but, unfortunately, the names have been transposed in the legends.) According to F. W. Edwards, the larvae of both British species of *Culicella* feed mainly at the bottom and prefer open pools. When disturbed they wriggle beneath the leaves. Evidently they shun the surface, and may well be on the way to developing similar habits to

Taeniorhynchus. Mr. Edwards suggests that it is even possible that that genus may have been derived from *Culicella*.

C. morsitans appears to be mainly a British species, and in Britain to be somewhat commoner than *C. fumipennis*. The type-specimen is from Eridge, Sussex. There are specimens in the British Museum Collection from Ghent and Southern France, and de Meijere records it from Holland (Tidschrift v. Ent., 1911, vol. liv, p. 138). It also occurs in Denmark and Macedonia. British records are as follows:—

Bucks.—Burnham Beeches; 10, vi, 1907; colld. C. O. Waterhouse; 6, v, 1914; colld. F. W. Edwards. *British Museum Collection.*

Essex.—Epping Forest; larvae; 21, iv, 1918; one pupated 24. iv. and emerged 1, v; and another pupated 23, iv, and emerged 29, iv; *colld. Lt. Tickner Edwardes, R.A.M.C.;* pupa, 13, v, 1918, emerged 16, v. 1918; *colld. Miss Cheesman.*

Rochford; 11, 12, and 15, vi, 1907; colld. Rev. A. E. Eaton. *British Museum Collection.*

Hants.—Brockenhurst; 30 and 31, iv, and [illegible], 15, and 28, v, 1918; colld. C. O. Waterhouse. *British Museum Collection.*

Lyndhurst; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Hunts.—Wood Walton Fen, E. of Ramsey; 13–15, iv, 1914; colld. F. W. Edwards. *British Museum Collection.*

Middlesex.—Harrow Weald Common; pupa; 28, iv, 1913; colld. F. W. Edwards. *British Museum Collection.*

Norfolk.—Ormesby, N. of Great Yarmouth; 25, vi, 1918; colld. G. H. Verrall. *British Museum Collection.*

Shropshire.—Longner Hall, S.E. of Shrewsbury; in garden, 16, vi, 1908; 5, vii, 1918; colld. R. F. Burton. *British Museum Collection.*

Suffolk.—Newmarket; 26, viii, 1908; colld. G. H. Verrall. *British Museum Collection.*

Surrey.—Mitcham Common; larvae; 3, v, 1918, pupated 7, v, 1918, emerged 15, v, 1918; pupa collected 3, v, 1918, emerged 6, v, 1918 *Colld. Miss L. E. Cheesman.*

Woking. See F. W. Edwards, 1912. *The Entomologist*, vol. xlv, p. 262.

Sussex.—Angmering Ponds, S.E. of Arundel; 4, vii, 1907; colld. Rev. A. E. Eaton. *British Museum Collection.*

Eridge, S. of Tunbridge Wells, Kent; type-specimen of *Culex morsitans;* colld. G. H. Verrall. *British Museum Collection.*

Patching Pond, N.W. of Worthing; 10, ix, 1907; colld. Rev. A. E. Eaton. *British Museum Collection.*

Wales.—Llanidloes, Montgomeryshire; 24, vii, 1918. *Colld. R. F. Burton.*

2. *Culicella fumipennis* (Stephens).

Figs. 70, 72, 78.

Culex fumipennis, Mihi.; J. F. Stephens, 1825, Zoological Journal, vol. i, p. 453.

Culicada Theobaldi, n. sp.: J. C. H. de Meijere, 1911, Tidschrift voor Entomologie, vol. liv, p. 142, pl. ix, figs. 10–16. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.

The white scaling at the sides of the proboscis in the female (fig. 70), and the length of the first fore-tarsal joint and the pattern of the underside of the abdomen in the male (fig. 72) are the only characters hitherto observed whereby the imago *Culicella fumipennis* can be distinguished from *C. morsitans* (see pp. 44–5). And since these differences are matters of degree, they are by no means as certain guides for determination as is desirable. I have not been able to discover any differences in the male genitalia. The larvae, however, have very different siphons (see figs. 77–8), and can be distinguished at a glance under sufficiently high magnification. It would be of great interest to determine by numerous experiments if these two species always bred true, and that they were not one species with a dimorphic larva. Also, since the genitalia are so similar, whether they would interbreed, and in that case whether the siphons of resulting larvae would exhibit dominance or mixed characters; and in the former case whether the 3 : 1 Mendelian proportion would occur in the second generation.

Culicella fumipennis appears to be nearly as common as *C. morsitans* and as widely distributed. De Meijere records it (as *Culicada Theobaldi*) from Holland, Noé from Italy, and Waterston from Macedonia.

British records are as follows:—

Bucks.—Burnham Beeches; larvae and flies; 6, v, 1914; colld. F. W. Edwards. *British Museum Collection.*

Dorset.—Burton Mere; 27, v, 1919; colld. Rev. A. E. Eaton. *British Museum Collection.*

Littlesea, Studland; 2, viii, 1911; colld. Rev. A. E. Eaton. *British Museum Collection.*

Studland; 21, v, 1912; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Hants.—Brockenhurst; flies and larvae; 15, v, 1924; 3, 10, 12, and 13, vi, 1905; 15, vi, 1906; colld. C. O. Waterhouse. *British Museum Collection.*

Middlesex.—Harrow-on-the-Hill; 14, v, 1905; colld. W. D. Lang. *British Museum Collection.*

London, British Museum (Nat. Hist.), Diptera Room; 4, ix, 1916; colld. F. W. Edwards. *British Museum Collection.*

Shropshire.—Longner Hall, S.E. of Shrewsbury; in garden, 10, vi, 1908; colld. R. F. Burton. *British Museum Collection.*

Shrewsbury; on windows in Board Room, Shrewsbury Infirmary; 3, ix, 1910; colld. R. F. Burton. *British Museum Collection.*

Surrey.—Ripley, N.E. of Guildford; type-specimen; colld. J. F. Stephens. *British Museum Collection.*

Wales.—Llanidloes, Montgomeryshire; 24, vii, 1918. *Colld. R. F. Burton.*

Scotland.—Dingwall, Cromarty; 31, v, 1911; colld. Lt.-Col. Yerbury. *British Museum Collection.*

Inveran, Sutherland; 17, vii, 1886; colld. G. H. Verrall. *British Museum Collection.*

VIII. CULEX, Linnaeus.

Culex; Linnaeus, 1758, Systema Naturae, Regnum Animale, editio decima, p. 602. Genosyntypes, *C. pipiens*, *C. fatigans*, *C. pallidus*, *C. pipiens*, *C. reptans* and *C. stercoreus*. Genolectotype, *C. pipiens;* see D. W. Coquillett, 1910, Proc. United States National Museum, vol. xxxvii, p. 529.

1. *Culex pipiens* Linnaeus.

Figs. 1, 16, 19, 22, 32, 70, 120–8.

Culex pipiens; Linnaeus, 1758, Systema Naturae, Regnum Animale, editio decima, p. 602.

Culex bicolor, J. F. Stephens, 1825, Zoological Journal, vol. 1, p. 488; from Hertford. (Probably *Culex bicolor*, Meg.; J. W. Meigen, 1818,

Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 9. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

Culex lutescens ; J. F. Stephens, 1825, *loc. cit. ;* from Darenth. (*non Culex lutescens ;* J .C. Fabricius, 1775, Systema Entomologiae, p. 800. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

Culex punctatus ; J. F. Stephens, 1825, *loc. cit. ;* no locality is recorded. (*non Culex punctatus ;* J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 9. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

Culex marginalis, Mihi. ; J. F. Stephens, 1825, *op. cit.* p. 455 ; one female ; London. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.

Culex rufus ; J. F. Stephens, 1825, *op. cit.*, p. 456 ; from Hertford (common). (*non Culex rufus*, Hoffmgg. ; J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 7. See F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 277.)

Culex domesticus (partim) ; J. F. Stephens, 1825, *op. cit.*, p. 455 ; from Hertford. (Probably *Culex domesticus ;* E. F. Germar, 1817, Reise nach Dalmatien und in das Gebiet von Ragusa, p. 290.) Three specimens under this name in Stephens' collection in the British Museum are *Culex pipiens* and one *Culex nemorosus*.

Culex sylvaticus ; J. F. Stephens, 1825, *op. cit.*, p. 454 ; one specimen, in June, from Coombe Wood. (*non Culex sylvaticus ;* J. W. Meigen, 1818, Systematische Beschreibung der bekannten Europäischen zweiflügeligen Insekten, vol. i, p. 6, which is *Ochlerotatus nemorosus*, *q.v.*)

The male *Culex pipiens* may be known at once from other British gnats, except *C. apicalis*, by the pointed palpi which curl upwards through an angle of about 90° (fig. 19). The female may be known from *Aëdes* and *Ochlerotatus* by the blunt abdomen (fig. 16) and simple claws ; and from *Taeniorhynchus*, *Theobaldia* and *Culicella* by the long first hind-tarsal joint (fig. 32). The long fork and short stalk of vein 2 of the wing is also an easily seen character distinctive of *Culex*. The creamy colour of the pale abdominal bands and their basal position distinguishes both sexes of *Culex pipiens* from *C. apicalis*. The larva is known by its long slender siphon (less slender than that of *C. apicalis*) and several scattered hair-tufts with few hairs.

Culex pipiens is quite the commonest British gnat, and is abundant everywhere. It is the more noticeable, as it frequents houses and, with *Anopheles maculipennis* and *Theobaldia annulata*, spends the winter as an impregnated female fly in the shelter of buildings.

Any collection of water that is not too foul serves as a breeding-place. Water-butts and zinc cisterns, as well as ponds in various situations, in fact, any stagnant water appears to satisfy the larvae of *Culex pipiens*. One unusual situation is recorded by A. Macdonald, jun., from Culross, Fifeshire. He found larvae in collections of water in a disused saw-pit in what had been a copse situated on a moor; but the trees had lately been cut down, so that where the water was there was now no shelter at all. The water was dark-coloured, but clear. Foreign records show *Culex pipiens* larvae to be still less particular in their breeding-places. H. Dyar, L. Howard and F. Knab (1915, Mosquitoes of North and Central America and the West Indies, vol. iii, p. 367) say that the larvae are able to thrive in highly polluted water, and quote catch-basins of sewers and water highly charged with the refuse from slaughtered animals as localities for them. They also quote Ficalbi as recording the larvae of *Culex pipiens* from fonts of consecrated water in churches and in sulphurous water; and J. Waterston (1918, Bull. Ent. Research, vol. ix, p. 10) found them in Macedonia in an artificial washing-pool amid soap-suds, and in extremely foul-smelling, but quite clear, rocky pools of a sewage effluent. It is probable, then, that in England *Culex pipiens* is no more particular in its breeding-places, but for lack of observation it is not credited with such foul propensities.

C. pipiens occurs throughout Europe, in northern Africa, E. Africa, Madagascar, and restrictedly in N. America. From the last-mentioned fact, Dyar, Howard and Knab consider that the species has been introduced into N. America from Europe. It is worthy of note that *Culex fatigans*, a species so much resembling *Culex pipiens* that the only satisfactory characters for distinguishing the two species are in details of the male genitalia, has a very wide geographical distribution in the warmer parts of the world, and has been recorded (F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. ii, p. 154) from Spain and Portugal. Now it is evident that, since the two species are so much alike that it needs a microscope-preparation before their differences can be seen, it may easily happen that *Culex fatigans* may be present in a country without being detected; for if *C. pipiens* is common, *C. fatigans* will not be sought. Also it is possible that if *C. fatigans* were to extend its range it might be a

long time be unnoticed. The practical interest of *C. fatigans* is that it conveys (and presumably can transmit) the worms that cause filariasis and the organism that causes dengue fever. It is desirable, therefore, that *C. pipiens* should be closely watched in case *C. fatigans* extended its range; and the possibility should not be forgotten of *C. pipiens* acquiring the disease-bearing habits of *C. fatigans* where the range of these species overlap, and by this means spreading the diseases concerned over its own range.

Culex pipiens, Linnaeus; var. *doliorum*, Edwards.

Culex pipiens, var. *doliorum* (nov.); F. W. Edwards, 1912, The Entomologist, vol. xlv, p. 263.

Culex nigritulus, Zetterstedt; F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. ii, p. 140.

non Culex nigritulus; J. W. Zetterstedt, 1850, Diptera Scandinaviae, vol. ix, p. 3459.

Edwards describes as a variety of *Culex pipiens* a form which is much smaller, darker, and having a thorax without any reddish tint, and recognises it as identical with British specimens referred by Theobald to *Culex nigritulus*, of Zetterstedt. Theobald's specimens were from larvae living in water-butts, but the locality is not mentioned. Edwards' type-specimen of his variety *doliorum* was also reared from a larva which with others was "swarming in water-barrels at Kingswear, S. Devon." They were found in October, 1911. A single specimen from Bushey Heath, Herts, and collected by F. W. Edwards, 27, vii, 1912, is in the British Museum Collection.

2. *Culex apicalis*, Adams.

Figs. 73, 129.

Culex apicalis, n. sp.; Adams, 1903, Kansas Univ. Sci. Bull., vol. ii, p. 26.

Culex pyrenaicus, n. sp.; Brölemann, 1919, Ann. Soc. Ent. France, vol. lxxxvii, p. 427.

Culex hortensis, Ficalbi; F. W. Edwards, 1915, Entomologist's Monthly Magazine, ser. 3, vol. i, p. 167.

non Culex hortensis; E. Ficalbi, 1889, Bull. Soc. Ent. Italiana, vol. xxxi, p. 217.

Culex apicalis resembles the more southern and eastern species *C. hortensis*, but has broader wing-scaling and no white spot at the distal end of the tibia. A single specimen of this species was taken

by F. Jenkinson at Logie, Elgin, N.B., 11, ix, 1911, and is now in the Cambridge University Museum. The type-specimen came from N. America, and that of *C. pyrenaicus* from the Pyrennees; and the latter form has also been taken at Rambouillet and la Creuse in France (see J. Villeneuve, 1919, Bull. Soc. Ent. France, p. 55).

IX. ORTHOPODOMYIA, Theobald.

Orthopodomyia, nov. gen.: F. V. Theobald, 1904, Ann. Entomological Soc. vol. xxxvii, p. 236. Genotype, *O. alipes*, n. sp.

1. *Orthopodomyia albionensis*, MacGregor.

Figs. 130–1–2.

Orthopodomyia albionensis, sp. nov.; M. E. MacGregor, 1919, Journ. Roy. Army Medical Corps, vol. xxxiii, p. 451, and plate.

? *Culex pulchripalpis*, N.; C. Rondani, 1872, Bull. Soc. Ent. Ital., anno iv, p. 31.

? *Culex pulchripalpis*, Rondani (1872); E. Ficalbi, 1899, Bull. Soc. Ent. Ital., anno xxxi, p. 220.

non Culex pulchripalpis; F. V. Theobald, 1901, A Monograph of the Culicidae or Mosquitoes, vol. ii, p. 16, which is *Ochlerotatus caspius*, q. v.

Orthopodomyia albionensis is easily distinguished from all other British gnats by the long palps of the female (fig. 130) and by the fourth tarsal joint of that sex (fig. 131) which, at least in the fore-leg, is not longer than broad. The general black ground-colour with brilliant white (not creamy) markings also distinguish both sexes from all the British forms except *Finlaya geniculata* and *Stegomyia fasciata* (added to the British list while this work was in the press, see p. 112). The complete white abdominal bands and white-banded tarsi distinguish it from the former, and its larger size and three pairs (instead of two pairs) of white longitudinal stripes on the dorsal surface of the thorax distinguish it from *Stegomyia fasciata*, as well as the absence of the silvery-white lateral row of abdominal spots of that species, and the larva has no pecten on an otherwise normal siphon (fig. 132).

In July of this year (1919), Major A. Macdonald collected some larvae in Epping Forest from a tree-hole from which he had formerly obtained the larvae of *Anopheles plumbeus*. They were reared by

Capt. M. E. MacGregor at Sandwich, Kent, and the emergent flies were mostly *Finlaya geniculata*. Among them, however, appeared four *Orthopodomyia*, described by MacGregor as a new species. But Rondani's original diagnosis of *Culex pulchripalpis*, and Ficalbi's later more detailed description do not leave the matter free of doubt; and it may be that the Epping Forest specimens are of Rondani's species Until it is possible, therefore, to compare Italian with the English material, it is better to accept MacGregor's name for this form.

FIG. 130.—Head of female *Orthopodomyia albionensis*, showing the rather long palps.

FIG. 131.—End of fore-tibia and fore-tarsus of female of the same species, showing short fourth tarsal joint.

Through the kindness of Major A. Macdonald and Capt. M. E. MacGregor, a specimen of each sex of *Orthopodomyia albionensis* is in the British Museum. On the 31st July, Mr. F. W. Edwards and Capt. MacGregor visited the tree-hole and collected a good deal of material. That brought back by Mr. Edwards yielded only *Finlaya geniculata*; but from Capt. MacGregor's material emerged a few *Orthopodomyia* and two specimens of *Stegomyia fasciata*, a second mosquito new to Britain from this tree-hole. On another visit, on 11th August, to the same tree-hole, Mr. Edwards secured a single

larva of *O. albionensis* in the fourth instar, and five pupae, three of which he reared to the imago-stage. Again, in September, Mr. H. Main took three more larvae, one in the second and two in the third instar, close to the spot in Epping Forest whence the others were obtained. These are still (Jan. 1920) alive, one in the third and the other two in the fourth instar, and it is likely that will hibernate in this condition.

It is a great encouragement to collectors that, while this work was in the press, this and two other species new to Britain, namely, *Ochlerotatus curriei* (see p. 84) and *Stegomyia fasciata* (see p. 112) have been discovered.

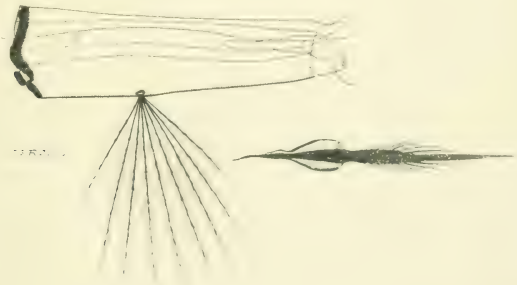

FIG. 132.—Siphon and comb-scale of the fourth-instar of larva of same species.

IV. REPUTED, DOUBTFUL, AND FOSSIL BRITISH SPECIES.

Stephens (1825, Zoological Journal, vol. i, pp. 452–456) recorded as British several of Meigen's species which have not since been found. Fortunately, Stephens' collection is in the British Museum, and his determinations have been revised by Mr. F. W. Edwards (see The Entomologist, 1912, vol. xlv, p. 277). All are referable to known British species. References to these are included in the synonymy under the account of the species to which they refer.

Besides these there are the following records of foreign species from Britain :—

Culex lutescens : J. C. Fabricius, 1775. Systema Entomologiæ, p. 806. Recorded as British by F. V. Theobald, 1901. A Monograph of the

Culicidae or Mosquitoes, vol. ii, p. 168, from Kingston-on-Thames, in 1885; but the specimen no longer exists. Also by G. H. Verrall, 1888, A List of British Diptera, p. 10.

Stegomyia fasciata (Fabricius). *Culex fasciatus;* J. C. Fabricius, 1805, Systema Antliatorum, p. 36. Two specimens of this mosquito emerged from the pupal material (otherwise *Finlaya geniculata*) collected by Capt. M. E. MacGregor from the tree-hole in Epping Forest from which the larvae and pupae of *Orthopodomyia albionensis* had already been obtained (see above). *Stegomyia fasciata* is the mosquito concerned in conveying Yellow Fever; and, being a ready breeder, is reared extensively in research laboratories in England. It would not, therefore, be a matter for surprise had escaped specimens of the fly been taken from the neighbourhood of laboratories. But to find it in the larval and pupal stages in Epping Forest is another matter, and it appears likely that, if no mistake has been made, this is a genuine case of the introduction of a foreign species. It will be interesting to note whether the species will survive the winter in the locality where it appears to be established. *Stegomyia fasciata* differs in general appearance from all other British forms, except *Finlaya geniculata* and *Orthopodomyia albionensis*, in being a black species with brilliant white markings; and from the two species mentioned in being much smaller and having a pair of sickle-shaped white bands on the thorax, a second pair of straight, yellowish, longitudinal lines between these, and a lateral row of silvery-white spots on the abdomen in addition to the usual banding. *Orthopodomyia albionensis* has three pairs of very narrow, white, longitudinal lines on the thorax, *Finlaya geniculata* has a median, pale, greenish-yellow line and a pair of similar lateral lines on the dorsal surface of the thorax, and lacks the white tarsal bands of the other two species (see M. E. Macgregor, 1919, Bull. Ent. Research, vol. x, p. 91).

Before leaving the subject of reputed British species, it is worthy of remark that there is a widespread belief in the occurrence of foreign gnats ("mosquitoes" they are generally called in this connection) introduced into this country by means of ships. The belief appears in letters written to the Museum, in entomological literature (see the case of the "Norway Mosquito" recorded in the Entomological Monthly Magazine, 1895, p. 227, which was merely *Ochlerotatus caspius*), and finds perennial expression in the Press; there is an echo of it in Theobald's remark on *Culex pulchripalpis* (see under *Ochlerotatus*

caspius, p. 83); and it is a possible explanation of the remarkable and isolated occurrence of *Culex apicalis*, an American and Mediterranean species, in Elgin (see p. 108), and the single case of *Stegomyia fasciata* quoted above. But, apart from the fact that, though by no means impossible, such introduction is unlikely,[1] there is no positive evidence that any gnat taken in Britain was introduced, and all supposed cases (except the two last mentioned) that have been investigated have proved to be ordinary British species. Such rumours, then, should be treated with scientific scepticism, and conclusive evidence demanded.

Though beyond the original intention of this work, it is of interest to observe that at least three species of gnat are found as fossils in Britain. These are from the Oligocene of Gurnard Bay, W. of Cowes, Isle of Wight, and are described by T. D. Cockerell, 1915, Proc. United States National Museum, vol. xlix, pp. 488–9, pl. lxi, fig. 12, and pl. lxii, figs. 1 and 2. They are named as follows:—

Culex protolepis, Cockerell, *op. cit.*, p. 488, pl. lxii, fig. 1.
Culex protorhinus, Cockerell, *op. cit.*, p. 488, pl. lxii, fig. 2.
Culex petrifactellus, Cockerell, *op. cit.*, p. 489, pl. lxi, fig. 12.

From the figures and descriptions of these forms it is evident that they are Culicidae, but a more exact determination is not possible. To assign them to the genus *Culex* is but conjecture.

Gnats have also been described from the Baltic amber, which probably is also Oligocene in age. And since Baltic amber is frequently picked up on our eastern coasts, it is possible that its gnat-fauna may be found in Britain.

V. EVOLUTIONARY AND CONCLUDING REMARKS.

It is evident from the foregoing account that there is much yet to be found out about British Mosquitoes. About their structure, for there may be many other differences than those given in the diagnostic tables, and these may be more definite and more easily seen than those characters which are given; besides, the first two

[1] Except in the case of the "cultivated" Mosquitoes.

larval instar of *Ochlerotatus detritus* have not been described ; and only the last larval instar of *Taeniorhynchus richiardii*, *Aëdes cinereus*, *Ochlerotatus vexans*, *O. waterhousei*, *O. annulipes*, *O. rusticus*, *Culicella morsitans*, *C. fumipennis* and *Orthopodomyia albionensis ;* and no larval stage of *Ochlerotatus curriei*. And about their habits, both as flies and larvae ; the times of appearance of the former, their distribution, the stations they mostly frequent, their enemies and other adverse circumstances affecting them, the kind of prey they prefer (for instance, *Culex pipiens* is said especially to attack birds), and their mating habits ; and, in observing the larvae, the kind of water they like best, the amount of impurities they can stand, the nature of their food and of their foes, and the behaviour in the winter of those that hibernate, are instances of what needs to be done. The remarks on pp. 5–11 illustrate the directions and scope of some of the conclusions to be drawn from the habits of mosquitoes. And, though a knowledge of the structure of each instar of every species is of immediate use for identification, it is of still greater interest if it points to possible conclusions concerning the evolution of gnats. The study of post-embryonic growth-stages as affording evidence of the phylogeny of any group is becoming more widely pursued by biologists, and has been applied with encouraging results especially by those whose work lies among fossil organisms. And one of the commonest occurrences met with by palaeontologists is that of homœomorphy both in convergent and in parallel evolution —homœomorphs being organisms closely resembling one another, yet having a different ancestry manifested in differing post-embryonic growth-stages. Hence, if two gnats resemble one another so closely that their separation is a matter of considerable trouble, it is not surprising to find their larvae differing considerably, as in *Culicella morsitans* and *C. fumipennis*. Again, it is probable that such larvae, in common with other more distantly-connected species, will resemble one another more closely in the earlier instar. Thus, a larval difference (unless, as in *Taeniorhynchus*, the larval peculiarity is obviously the result of direct adaptation to a peculiar environment) is probably of more significance than a difference in the imago. This principle has been recognised as fundamental by American authors, notably by Dyar and Knab, and they accordingly classify mosquitoes primarily with regard to their larval characters.

A glance at the British forms will show the value of some of the larval characters. It is evident that the genus *Anopheles* differs more from the other genera of gnats than these do among themselves ; but the larval differences are more striking than those of the imago. And even the first larval instar of *Anopheles* differs considerably from the first larval instar of a Culicine—notably in possessing no siphon, in having anterior clypeal hairs, float-hairs and the scales of the comb united basally. It is even possible that the "secondary comb" of the first instar *Anopheles* with its separated scales is the homologue of the comb of the Culicines. It is likely, then, that *Anopheles* diverged from the main stock before this had divided into various Culicine lineages. The first instar (as far as it is known) of the various Culicine genera have the hair on the siphon approximately in the position of the hair-tuft in the later instar ; and this renders it likely that the genera *Aëdes*, *Finlaya* and *Ochlerotatus* diverged along one line, *Theobaldia*, *Culicella*, and possibly *Taeniorhynchus* along a second line, and *Culex* along a third line. It is evident from an examination of the first larval instar of various species that the arrangement of the comb-scales in a single disconnected row is a primitive one. This primitive condition is retained in *Aëdes*, *Finlaya* and *Taeniorhynchus* throughout their larval life. It is of interest to note that this primitive line has apparently *independently* broken up into a triangular patch with the scales irregularly arranged in *Ochlerotatus*, in *Theobaldia* (and presumably *Culicella*) and in *Culex*. From the first instar, too, it is seen that the arrangement of the post-antennal hairs is approximately in a line. In the second, third and fourth larval instar of *Ochlerotatus*, the mid post-antennal hair has moved forward and inward, showing that in this character *Ochlerotatus* has advanced beyond the other allied genera.

The arrangement of the larval hairs has been considered from an evolutionary point of view. What of their form? Culicid larvae are remarkable for the extraordinary variety of form displayed in the hairs springing from the integment. These may be apparently simple, split at the end, slightly branched, once or twice bifurcate, pinnately branched or feathered, dendroid, tufted, with flattened laminae forming rosettes (as in float-hairs) or fringed scales (as in the comb), stiffened so as to be bristle-like or hardened into a spine

or tooth. It is reasonable to suppose that these are all modifications of a simple hair, and that various degrees of branching (from mere splitting of the end to a fringed scale or a tufted hair consisting of several sub-equal branches united at the base, and themselves having tiny secondary and pinnately-arranged branches) have been imposed upon the simple hair during evolution, and that the general development of a hair is an *anagenesis* from more simple to more complex. But in certain cases, hairs may be seen to be secondarily simple and to be in *catagenesis* or declining evolution. Such are the anterior clypeal hairs of *Anopheles plumbeus* in the last two instar. Those of the third instar (fig. 88) are more complex than those of the fourth (fig. 82), and those of the second (fig. 94) than those of the third instar. It is probable, too, that the smooth antennae of *Anopheles plumbeus*, *Finlaya geniculata*, and *Orthopodomyia* is a secondary condition correlated with their life in tree-holes; that is, that the appressed spines or scales were originally present, but were lost during evolution. There is, however, no ontological evidence in this case.

It is possible, while in all the cases hitherto mentioned, the hair, scale, or tooth is derived from a single hair, the pecten-teeth, on the contrary, are compound in origin, and that each tooth is comparable with the comb of the eighth segment. In the first instar of *O. nemorosus* the more distal pecten-teeth may have several smaller denticles *on each side* of a larger one, and are reminiscent of the very minute rows of graduated teeth that cover the siphon and chitinous "saddle" of the ninth segment.

It is often asked of what use to the organism is the comb or the pecten. For that matter, what use has been discovered for any of the marvellously-shaped hairs with which the larva is so abundantly adorned? The function of the palmate hairs of *Anopheles*, it is true, is to help the organism to float, and of the brushes to collect and direct particles of food. But in most cases a use has yet to be found for the hairs of Culicid larvae. But is it likely that every branch and every form of hair has an adaptive significance? I think not. Given an organ that during evolution begins to vary in a definite direction, certain variations will be seized upon and adapted to definite uses. But it often seems that a process in evolution once started continues with an increasing momentum, and often cannot be checked; and has

no relation to Natural Selection, except that it may cause extinction by hampering the organism. Such has almost certainly happened in connection with the skeletal structures of various organisms, and particularly in the matter of calcium carbonate secretion. In the case of the larval hairs, it is possible that a tendency to branching, flattening, and otherwise modifying the shape of a simple hair arose in primitive Culicid larvae; and as evolution proceeded this tendency gained in momentum in every lineage, and has progressed to the extremes now met with in present-day Culicids. Where it could be put to a use this was done, as in the case of the float-hairs. But often, if not generally, when confronted with a Culicid larval hair, we are dealing, not with a complex adaptation, but with a variation which has got out of hand possibly by the removal of some inhibiting factor, which made for conservatism in an organ with great potential variability.[1]

Before concluding, I would acknowledge, with many thanks, the ready assistance I have received from the following; chiefly in the shape of material, particularly of various larval stages, but also advice and information. Without this help the handbook, imperfect as it is, would be very greatly impoverished:—

John Archibald, Esq., late R.A.M.C.; R. F. Burton, Esq.; Miss L. E. Cheesman; Dr. J. Davidson, late Capt. R.A.M.C.; Dr. J. J. Day, late attd. R.A.M.C.; Tickner Edwardes, Esq., late R.A.M.C.; M. Gross, Esq., late Capt. R.A.M.C.; A. J. Grove, Esq., of the Local Government Board; Col. S. P. James; G. H. Lockett, Esq., and the boys of Gresham's School, Holt; Major A. Macdonald, R.A.M.C.; Angus Macdonald, jnr.; Major A. C. Parsons, R.A.M.C.; Mr. Ryan, late R.A.M.C.; Dr. Hugh Scott[2]; D. J. Scourfield, Esq.; C. D. Soar, Esq.; F. B. Taylor, Esq.; A. Vassall, Esq.; and my colleagues, Major E. E. Austen, D.S.O.; K. G. Blair, Esq.; G. R. Brook, Esq., late R.A.M.C.; F. W. Edwards, Esq.; and J. Waterston, Esq., late R.A.M.C.

[1] C. Wesenberg-Lund (1919, Vidensk. Meddl. fra Dansk naturhist. Foren., vol. lxx, p. [illegible]) accounts for the abundance and length of the larval hairs as an adaptation for [illegible] motions in the environment, but he does not account for the variations [illegible].

[2] By an oversight on p. 84, no acknowledgment to Dr. Hugh Scott was made for kindly presenting the Museum with specimens of [illegible], a species new to science collected by him near Wareham.

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